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COMPARISONS BETWEEN TRNSYS SOFTWARE SIMULATION AND F-CHART PROGRAM ON SOLAR DOMESTIC HOT WATER SYSTEM

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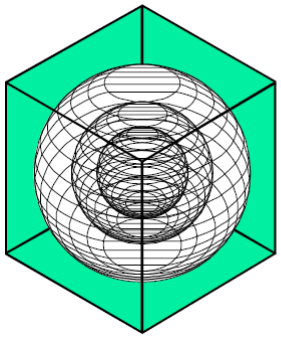

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1. EXECUTIVE SUMMARY

This study presents the accuracy test of a TRNSYS Solar Domestic Hot Water (SDHW) System simulation. The testing is based on comparing the results with the F-Chart software. The selected system to carry out the tests was the Active Solar Domestic Hot Water System in the F-Chart and the Houston TMY2 weather was used for the simulations. The comparison of the accuracy tests showed that solar fraction from the TRNSYS simulations are in a 0% - 19.6% range with respect to one that are performed by the F-Chart program.

This report is organized as follows:

- Section 1 is executive summary, which gives a overview of this project.
- Section 2 introduces and describes the components of a Solar Domestic Hot Water System (SDHW) and the products characteristics that were selected as the inputs for the simulations.
- Section 3 presents the adjusted TMY2 Houston Weather file that was created for F-Chart. The comparisons between the original TMY2 weather file and the TRNSYS TMY2 weather file are presented to confirm the weather file variations that affect the simulations. This adjustment is needed in order to have a fair SDHW system simulation comparison between the two software; TRNSYS and F-Chart.
- Section 4 includes the performance of the SDHW system base case simulation by both software, TRNSYS and F-Chart.
- Section 5 to Section 10 contain the detailed system analysis for six different parameter variation and establish TRNSYS simulation reliability.
- Section 11 has the summary of all the simulation analysis.
- Section 12 presents the final conclusion about this project and is followed by reference and appendix.

Table 1-1 summaries the simulation analysis that are performed for this report. Analysis 1-3 focuses on studying the simulation variations when changing solar collector area and water volume/collector area ratio. The collector area for analysis is $40ft^2$, $400ft^2$ and $4000ft^2$, respectively. The studied ratio for the three analysis are 0.93, 3, 5.9 and 7.3. Analysis 4-6 analyzes simulation variations when changing daily hot water usage. For analysis 4, the daily hot water usage cases are 50 gallons/day, 51 gallons/day, 55 gallons/day, 85 gallons/day, 106

gallons/day, 107 gallons/day, and 115 gallons/day. For analysis 5, the daily hot water usage cases are 10 gallons/day, 25 gallons/day, 55 gallons/day, 85 gallons/day, 115 gallons/day, 146 gallons/day, 147 gallons/day and 150 gallons/day. Finally, for analysis 6, the daily hot water usage cases are 10 gallons/day, 25 gallons/day, 55 gallons/day, 85 gallons/day, 115 gallons/day, 461 gallons/day, and 462 gallons/day.

Table 1-1 Solar Domestic Hot Water System Simulation Summary

	Settings		Reference	Base Case	Analysis 1				Analysis 2				Analysis 3				Analysis 4							Analysis 5								Analysis 6							
Flat-Plat Collector	No. of collector panels		64	2																																		
	Collector panel area	(ft^2)	1	32.04	40	40	40	40	400	400	400	400	4000	4000	4000	4000	40	40	40	40	40	40	40	400	400	400	400	400	400	400	400	4000	4000	4000	4000	4000	4000	4000
	FR*UL	(Btu/hr-ft^2-F)	1.07	0.847																																		
	FR*TAU*ALPHA		0.78	0.694																																		
	Collector slope	(degree)	30	29.8																																		
	Collector azimuth	(degree)	0	0																																		
	Inc angle modifier constant		Values	0.25																																		
	Collector flow rate/area	(lb/hr-ft^2)	11	11																																		
	Collector fluid specific heat	(Btu/lb-F)	1	1																																		
	Test collector flow rate/area	(lb/hr-ft^2)	11	4.98																																		
	Test fluid specific heat	(Btu/lb-F)	1	1																																		
Active Domestic Hot Water System	Location			Houston																																		
	Water volume / collector area	(gallons/ft^2)		1.186	0.93	3	5.9	7.3	0.93	3	5.9	7.3	0.93	3	5.9	7.3																						
	Fuel			Elec																																		
	Efficiency of fuel usage	(%)		70																																		
	Daily hot water usage	(gallons)		70													50	51	55	85	106	107	115	10	25	55	85	115	146	147	150	10	25	55	85	115	461	462
	Water set temperature	(F)		120																																		
	Environmental temperature	(F)		71.6																																		
	UA of auxiliary storage tank	(Btu/hr-F)		0																																		
	Pipe heat loss			No																																		
	Tank-side flow rate/area	(lb/hr-ft^2)		11																																		
	Heat exchager effectiveness			0.5																																		
Water Storage Space and DHW System	Location		Austin																																		
	Water storage volume	(gallons)	1000																																		
	Building UA (0 if only DHW)		0																																		
	Fuel		Elec																																		
	Efficiency of fuel usage	(%)	100																																		
	Daily hot water usage	(gallons)	60																																		
	Water set temperature	(F)	140																																		
	Environmental temperature	(F)	68																																		
	UA of auxiliary storage tank	(Btu/hr-F)	7.6																																		
	Relative load heat exchanger size		1																																		
Annual f		F-Chart	0.719	0.744	0.798	0.877	0.909	0.917	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.930	0.917	0.895	0.754	0.675	0.671	0.644	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
		TRNSYS	TRNSYS	0.852	0.877	0.942	0.961	0.965	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.986	0.941	0.939	0.930	0.857	0.798	0.794	0.770	1.000	1.000	1.000	1.000	1.000	0.997	0.997	0.996	1.000	1.000	1.000	1.000	1.000	0.989	0.989
	(from 120F->100C)	% Diff		-14.5%	-9.9%	-7.4%	-5.7%	-5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	-1.2%	-2.4%	-3.9%	-13.7%	-18.2%	-18.4%	-19.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	1.1%

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2 SOLAR DOMESTIC HOT WATER SYSTEM INTRODUCTION

2.1 Introduction

Solar Domestic Hot Water system in F-Chart Manual is selected, which is used to provide hot water demand through solar energy, shown in Figure 2-1. It consists of solar collector, heat exchanger, controller, two pumps, preheated storage tank, water heater and valves. Solar collector can collect the solar energy which is transferred through heat exchanger to preheated tank to heat up demand water to certain degree. The water heater, then, is used to heat the demand water to the desired temperature. The differential controller is used to control the collector outlet and tank outlet.

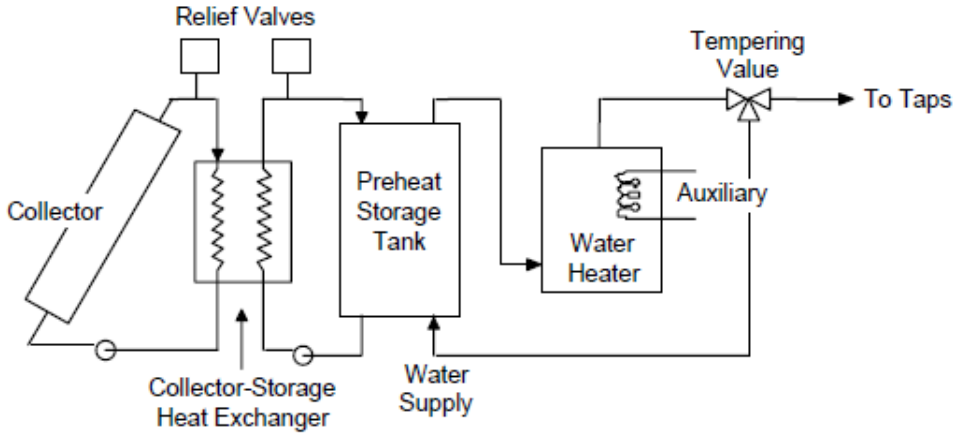


Figure 2-1Solar Domestic Hot Water System Diagram by F-Chart Manual.

2.2 Selected Products for Simulation

2.2.1 Solar collector

Two Thermo Dynamics, Ltd flat-plate collectors are selected to collect solar energy. The collector panel name is S32-P. Gross area is 32.04 ft^2 per collector and the aperture area is 29.96 ft^2 per collector.

2.2.2 Heat exchanger

The Heat exchanger from Shell-and-Coil™ is selected with 6.5 ft^2 heat transfer area. The overall Heat transfer coefficient is 6.7 Btu/hr-ft2-F.

2.2.3 Pre-heat tank

The brand for pre-heat tank is AO Smith SUNX-80 with 4500 Watt. The capacity is 76 gallons and R-16 is for the insulation. Basic dimensions are 63-1/4 inch height, 24 inch diameter.

2.2.4 Auxiliary Heater

The auxiliary heater is assumed to be lossless with 23 kW maximum heating rate.

3 WEATHER FILE DATA ADJUSTMENT

3.1 Overview

The TMY2 Houston weather is selected for both TRNSYS and F-Chart in order to simulate Solar Domestic Hot Water System (SDHW). However, the two weather files have differences in dry bulb temperature, main water temperature, etc. Therefore, in order to precisely simulate the SDHW system, weather data consistence is necessary. TMY2 weather from TRNSYS weather library is selected as the only weather input. The output weather information from TRNSYS component named Type 15-2 is then regards as a weather input for SDHW system in F-Chart. Figure 3-1 shows the system used to output hourly TMY2 Houston weather in TRNSYS simulation studio. This study is accomplished by in the SDHW previous report (Mao, Baltazar and Haberl, 2012).

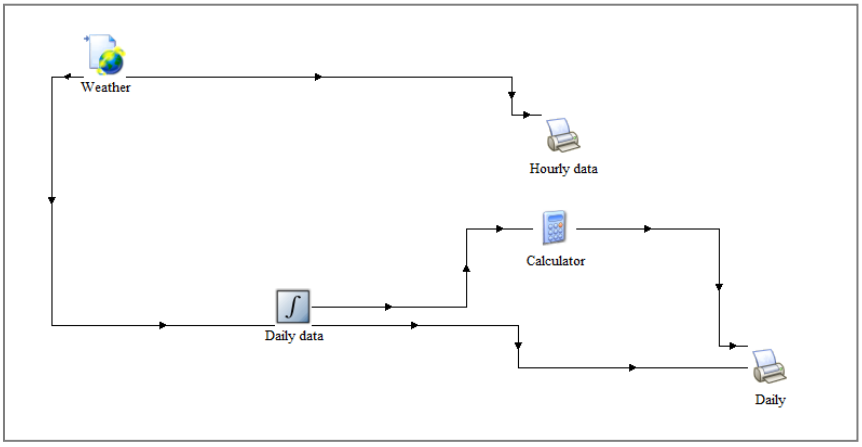


Figure 3-1 Output TMY2 Houston Weather by TRNSYS Components.

3.2 Hourly Weather Data Comparisons between Original TMY2 and TRNSYS Output

Before using TRNSYS output weather data, the accuracy of TRNSYS weather data needs to be tested. The original weather data in http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/tmy2/State.html is chosen. Three terms are compared, which are horizontal solar radiation, ambient temperature and relative humidity, respectively. Three time steps are set for TRNSYS component Type 15-2, which are 0.01hr, 0.25hr and 1 hr.

Figure 3-2 - Figure 3-4 details the comparisons of hourly horizontal solar radiation. The difference between Type15-2 output and original data is barely seen, which is shown as a red solid line.

However, the differences for the ambient temperature and relative humidity comparisons increase as the time step increases from 0.1hr to 1 hr., which are shown in Figure 3-5 - Figure 3-10.

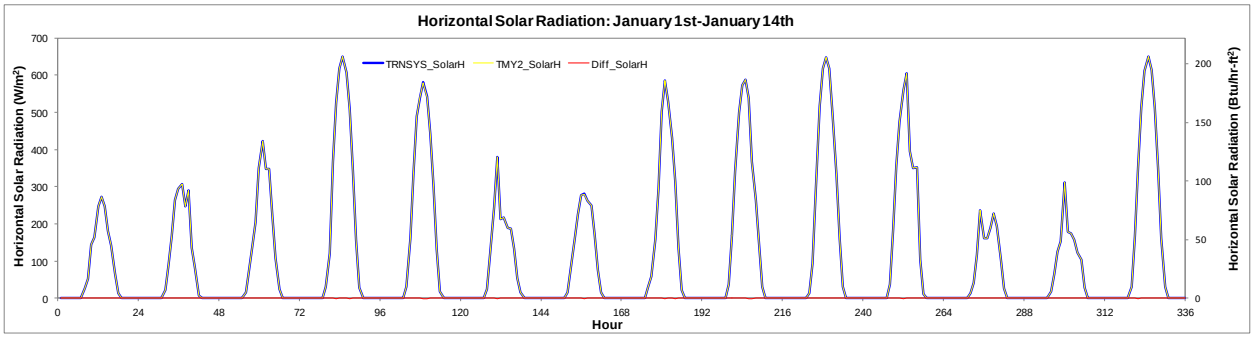


Figure 3-2 Hourly Horizontal Solar Radiation of TMY2 Original Weather File and TRNSYS Output (Timestep=0.01hr).

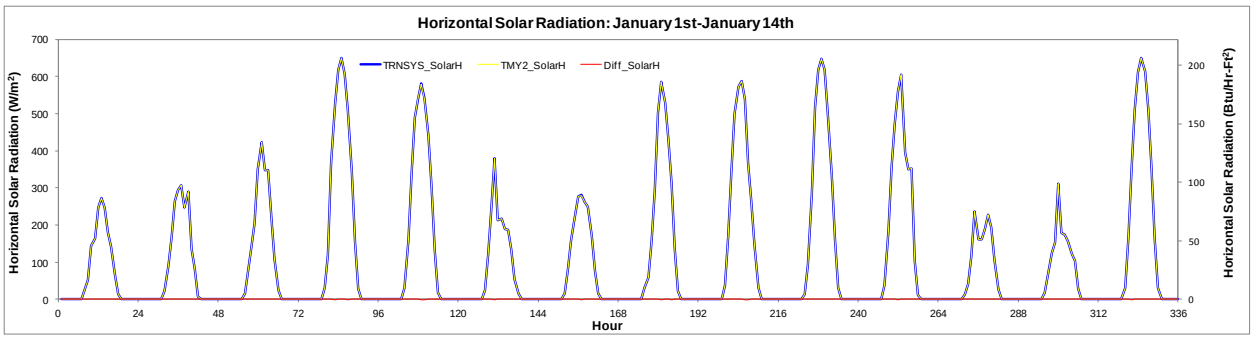


Figure 3-3Hourly Horizontal Solar Radiation of TMY2 Original Weather File and TRNSYS Output (Timestep=0.25hr).

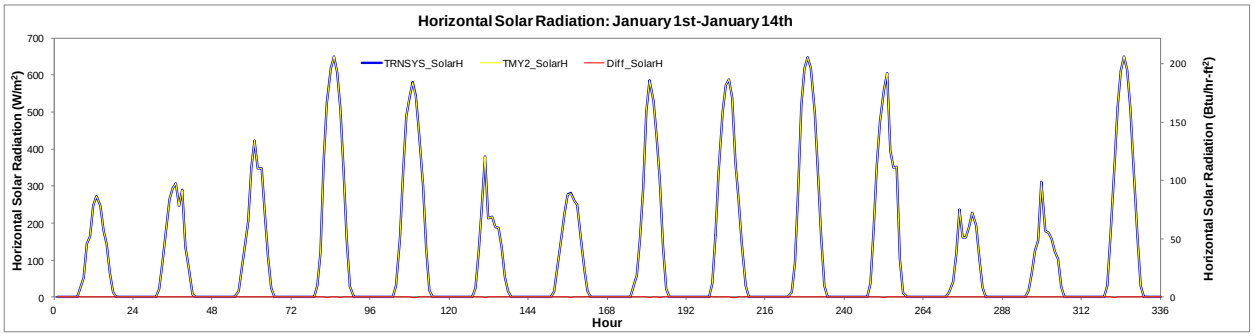


Figure 3-4Hourly Horizontal Solar Radiation of TMY2 Original Weather File and TRNSYS Output (Timestep=1hr).

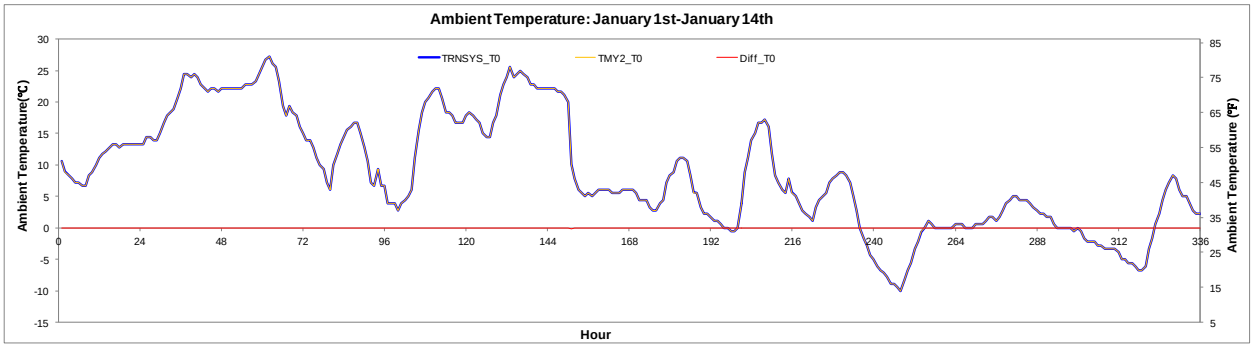


Figure 3-5Hourly Ambient Temperature of TMY2 Original Weather File and TRNSYS Output (Timestep=0.01hr).

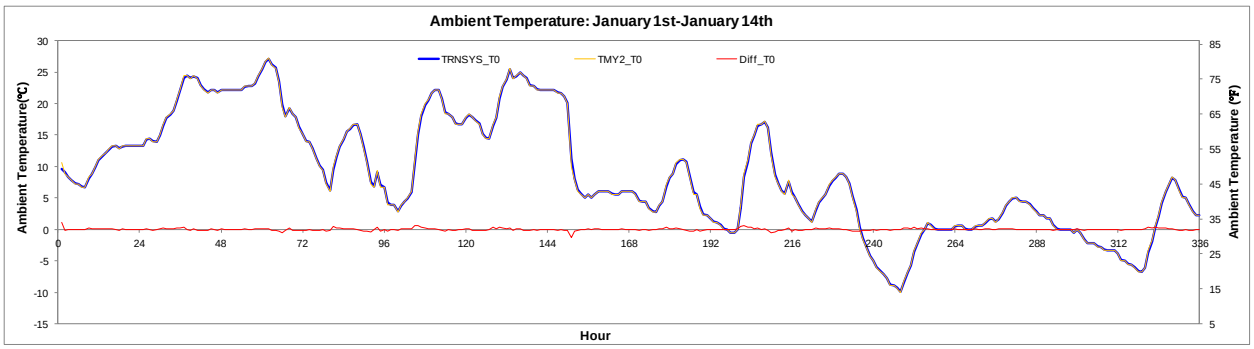


Figure 3-6Hourly Ambient Temperature of TMY2 Original Weather File and TRNSYS Output (Timestep=0.25hr).

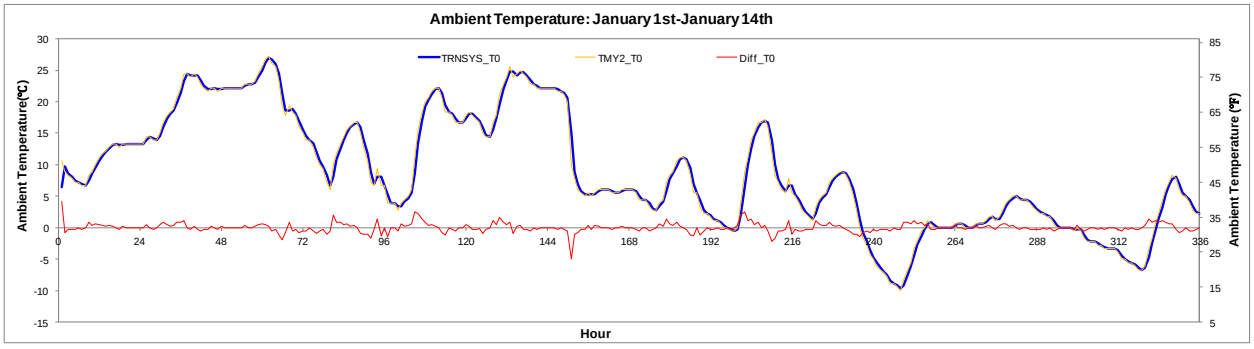


Figure 3-7Hourly Ambient Temperature of TMY2 Original Weather File and TRNSYS Output (Timestep=1hr).

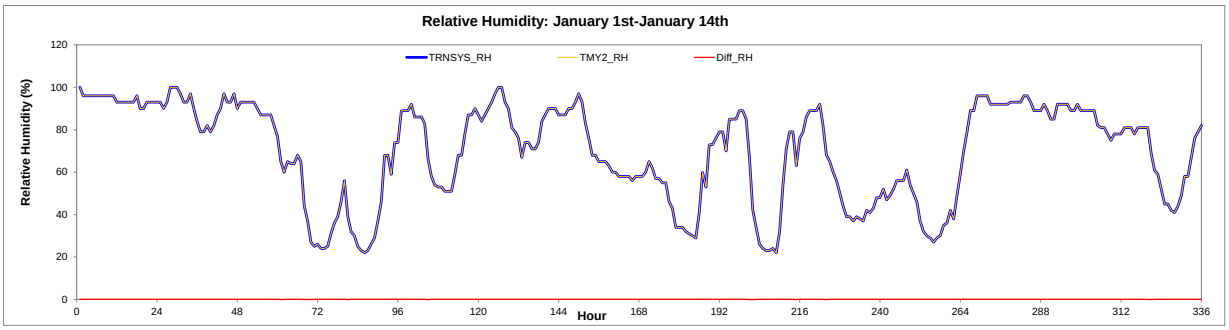


Figure 3-8Hourly Relative Humidity of TMY2 Original Weather File and TRNSYS Output (Timestep=0.01hr).

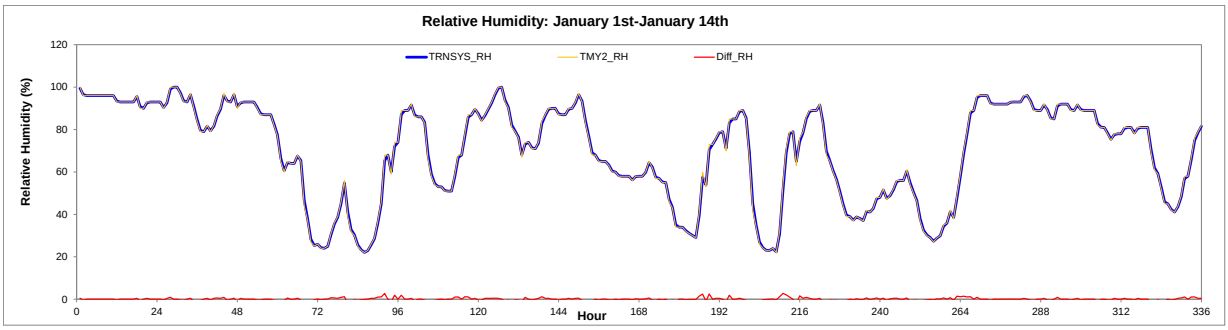


Figure 3-9Hourly Relative Humidity of TMY2 Original Weather File and TRNSYS Output (Timestep=0.25hr).

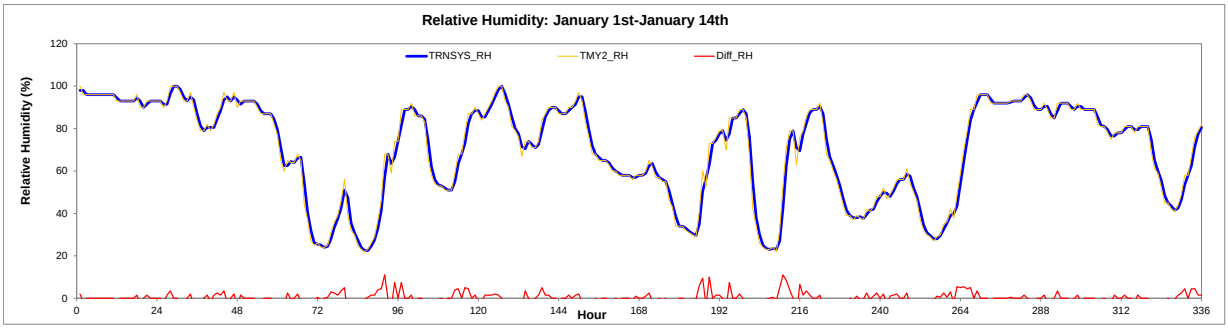


Figure 3-10Hourly Relative Humidity of TMY2 Original Weather File and TRNSYS Output (Timestep=1hr).

Cumulative errors are calculated for horizontal solar radiation, ambient temperature and relative humidity for both Houston TMY2 and Austin TMY2 weather data.

Table 3-1 summarizes RMSE, CV-RMSE, MBE and NMBE of Houston weather for three time steps. Figure 3-11 - Figure 3-13 show the tendencies of cumulative - error changes. For horizontal solar radiation, the cumulative error appears periodic pattern for three time steps while for ambient temperature and relative humidity, as time steps increases, the cumulative error increases.

Table 3-1 Summary of RMSE, CV-RMSE, MBE and NMBE-Houston Weather.

	Timestep=0.01hr			Timestep=0.25hr			Timestep=1hr		
	Solar H	AmbientT	RH	Solar H	AmbientT	RH	Solar H	AmbientT	RH
RMSE	0.4221	0.0035	0.0281	0.4221	0.1661	0.7383	0.4221	0.6625	2.9460
CV-RMSE	0.0635%	0.0177%	0.0373%	0.0635%	0.8283%	0.9803%	0.0635%	3.3046%	3.9112%
MBE	-0.003995	-0.000136	-0.000034	-0.003995	-0.003610	-0.009167	-0.003995	-0.017734	0.000000
NMBE	-0.0006%	-0.0007%	0.0000%	-0.0006%	-0.0180%	-0.0122%	-0.0006%	-0.0885%	0.0000%

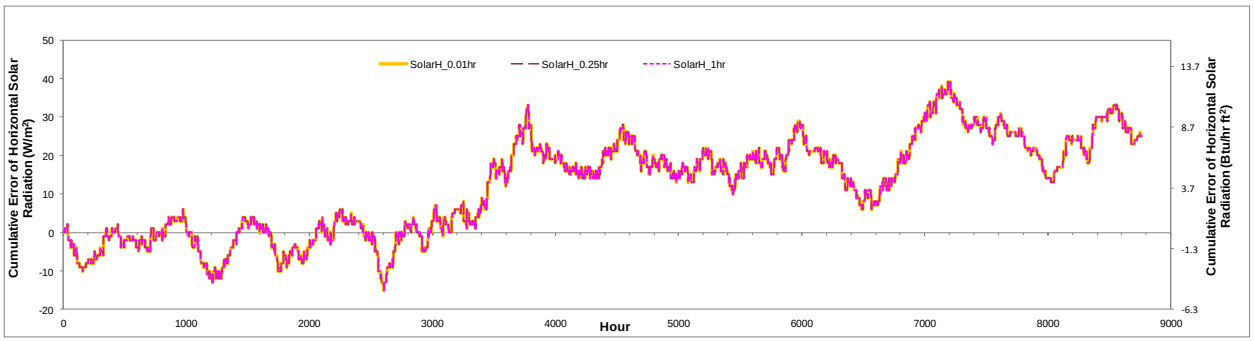


Figure 3-11. Cumulative Error of Horizontal Solar Radiation-Houston.

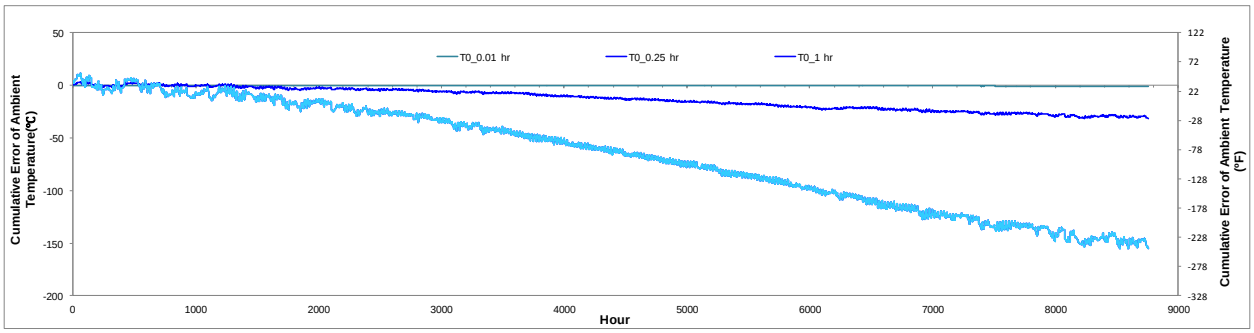


Figure 3-12. Cumulative Error of Ambient Temperature-Houston.

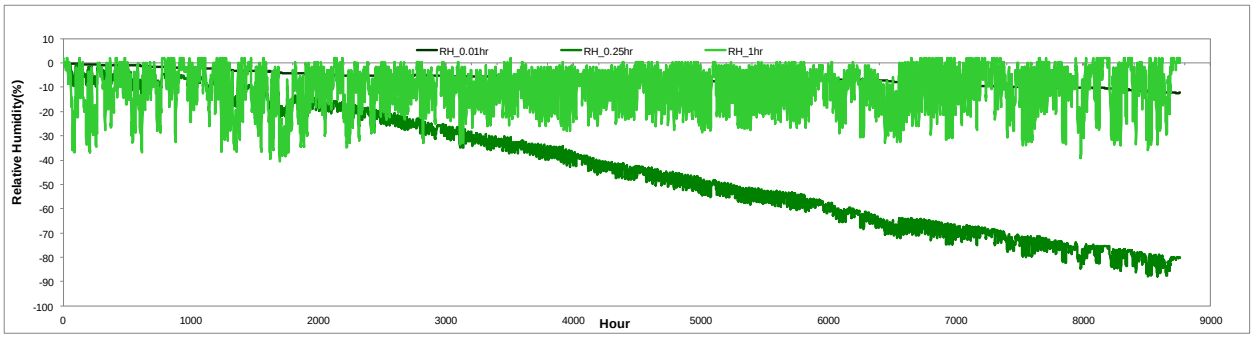


Figure 3-13Cumulative Error of Relative Humidity-Houston.

Table 3-2 summarizes RMSE, CV-RMSE, MBE and NMBE of Houston weather for three time steps. Figure 3-14 - Figure 3-16 show the tendencies of cumulative - error changes. For horizontal solar radiation, the cumulative error appears periodic pattern for three time steps while for ambient temperature and relative humidity, as time steps increases, the cumulative error increases. Those results show the same change patterns as Houston weather file.

Table 3-2 Summary of RMSE, CV-RMSE, MBE and NMBE-Austin Weather

	Timestep=0.01hr			Timestep=0.25hr			Timestep=1hr		
	Solar H	AmbientT	RH	Solar H	AmbientT	RH	Solar H	AmbientT	RH
RMSE	0.4412	0.0025	0.0232	0.4412	0.1572	0.6672	0.4412	0.6272	2.6607
CV-RMSE	0.0602%	0.0126%	0.0349%	0.0602%	0.7836%	1.0031%	0.0602%	3.1271%	4.0003%
MBE	0.002854	-0.000038	-0.001404	0.002854	-0.003180	-0.010537	0.002854	-0.018408	0.000000
NMBE	0.0004%	-0.0002%	-0.0021%	0.0004%	-0.0159%	-0.0158%	0.0004%	-0.0918%	0.0000%

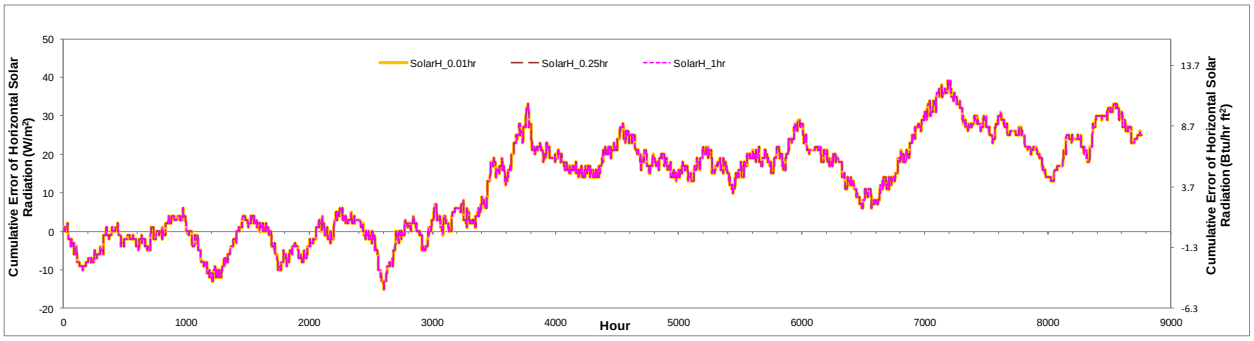


Figure 3-14Cumulative Error of Horizontal Solar Radiation-Austin.

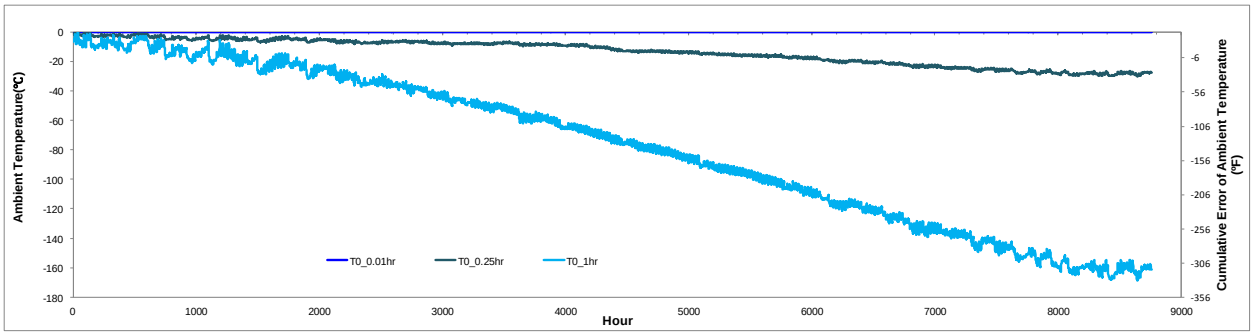


Figure 3-15Cumulative Error of Ambient Temperature-Austin.

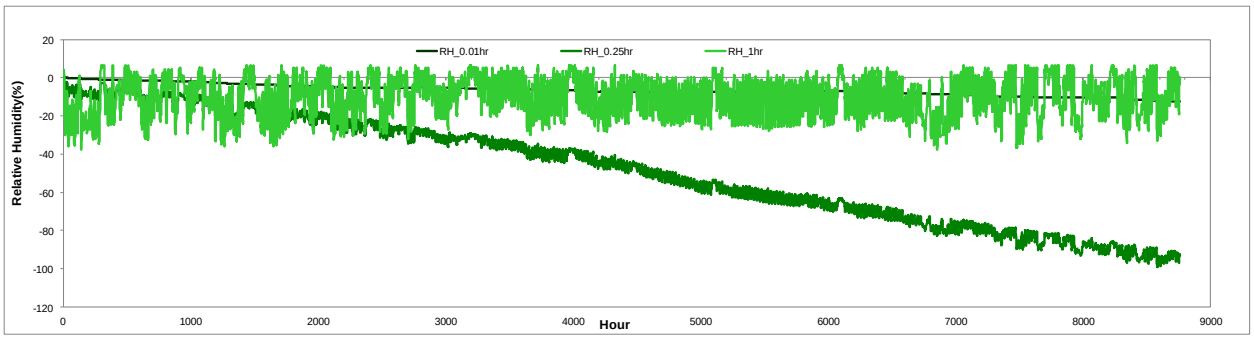


Figure 3-16Cumulative Error of Relative Humidity-Austin.

As time step increases from 0.1 hr to 1 hr, the difference between the original TMY2 weather and Type15-2 output weather data increases, which could influence the accuracy of F-Chart weather and even the SDHW system simulation.

3.3 Weather File Input for F-Chart

By using output weather data from TRNSYS component Type 15-2, the new TMY2 weather file is created, which is shown in Table 3-3. The new weather data is slightly different from the original weather data provided in F-Chart for solar radiation, ambient temperature, humidity, degree-days.

Table 3-3 The Created and Original Weather Files for F-Chart.

	F-Chart (New Weather)						F-Chart (Original Weather)					
	City: Houston, TX; Latitude: 29.9; Deg-day base:65						City: Houston, TX; Latitude: 29; Deg-day base:65					
	Solar Rad. (Btu/ft^2)	Temp. (°F)	Humidity (lb/lb)	Mains (°F)	Reflect.	F-days	Solar Rad. (Btu/ft^2)	Temp. (°F)	Humidity (lb/lb)	Mains (°F)	Reflect.	F-days
Jan	858	53.4	0.0074	67.0	0.2	370	842	50.7	0.0058	67.0	0.2	450
Feb	1061	51.6	0.0067	67.2	0.2	381	1082	54.0	0.0064	67.2	0.2	317
Mar	1354	61.2	0.0083	67.5	0.2	161	1345	61.3	0.0083	67.5	0.2	159
Apr	1558	68.9	0.0114	67.9	0.2	33	1588	68.7	0.0111	67.9	0.2	35
May	1778	75.1	0.0139	68.2	0.2	6	1781	74.8	0.0138	68.2	0.2	6
Jun	1940	79.8	0.0158	68.5	0.2	0	1908	80.1	0.0165	68.5	0.2	0
Jul	1865	82.4	0.0176	68.6	0.2	0	1884	82.0	0.0177	68.6	0.2	0
Aug	1752	81.1	0.0169	68.6	0.2	0	1776	81.7	0.0174	68.6	0.2	0
Sep	1553	77.5	0.0147	68.4	0.2	0	1543	77.7	0.0154	68.4	0.2	0
Oct	1344	69.7	0.0125	67.9	0.2	29	1328	69.3	0.0113	67.9	0.2	32
Nov	1011	62.8	0.0096	67.5	0.2	121	972	61.0	0.0085	67.5	0.2	159
Dec	768	52.6	0.0074	67.2	0.2	393	790	53.8	0.0065	67.2	0.2	358

4 SOLAR DOMESTIC HOT WATER SYSTEM SIMULATION COMPARISONS OF BASE CASE

4.1 Overview

In this section, a SDHW system is simulated by TRNSYS software as well as F-Chart. The system is created based on the system scheme in F-Chart manual, see Figure 4-1.

For base case, two collector panels are selected with each panel area of 32.04 ft^2. The test slope FR*UL is set to 0.847 and test intercept FR*TAU*ALPHA is set to 0.694.Collector slope is 29.8 degree which equals to College Station latitude. Incident angle modifier is chosen to be constant, 0.25. Typical collector flow per area, 11 lb/hr-ft^2 is used in the simulation. The liquid in solar collectors is assumed to be water.

To calculate the domestic hot water usage, the active domestic hot water system is adopted. The system locates in Houston, TX. The storage tank ratio (water volume/collector area) equals to 1.186.The lossless heater can heat the mains water up to 120 F to fulfill the domestic hot water usage 70 gallons/day.

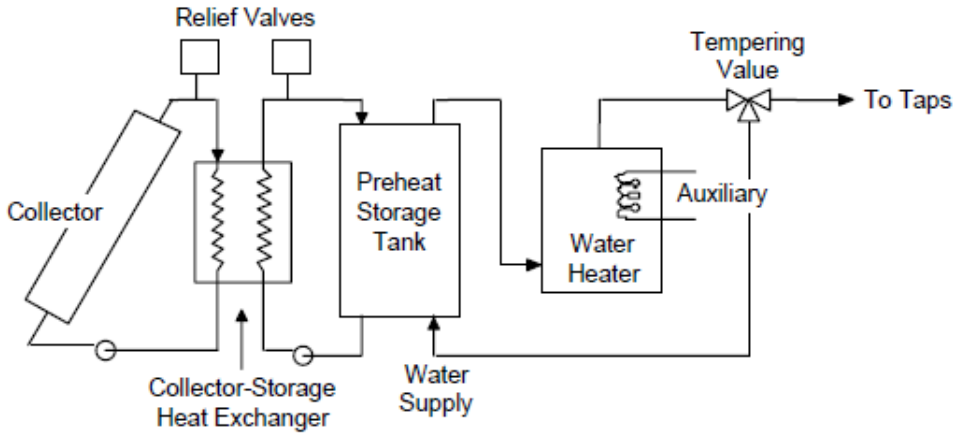


Figure 4-1 Solar Domestic Hot Water System in F-Chart Manual.

4.2 F-Chart Simulation

This section shows the SDHW simulation results by F-Chart. Figure 4-1 and Figure 4-3 summarize the F-Chart input. The final simulation results of SDHW system is shown in Figure 4-4, including monthly total solar radiation (Solar), monthly total water heating demand (Dhw), monthly total auxiliary energy (Aux) and f factor (f).

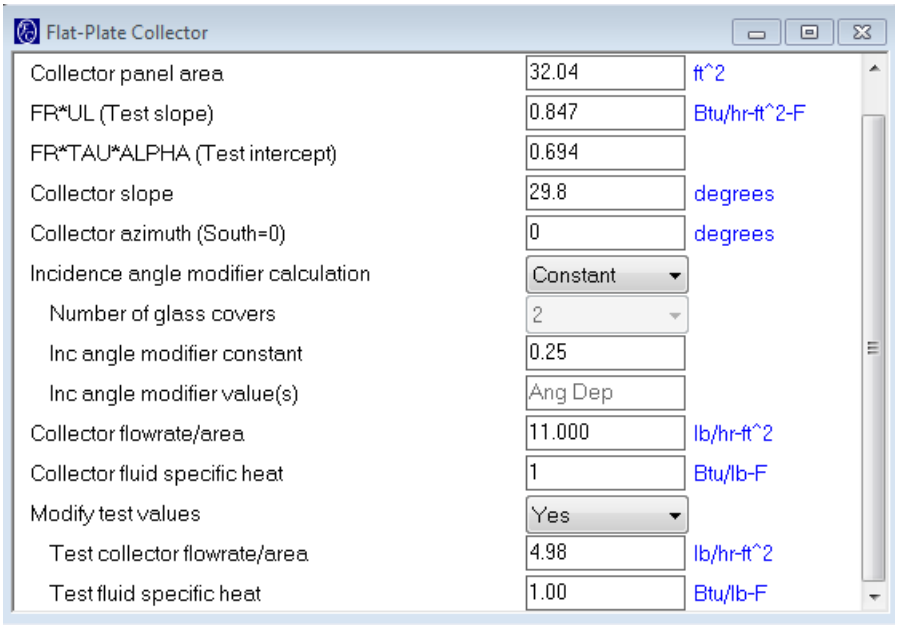


Figure 4-2 Flat-Plate Collector Input

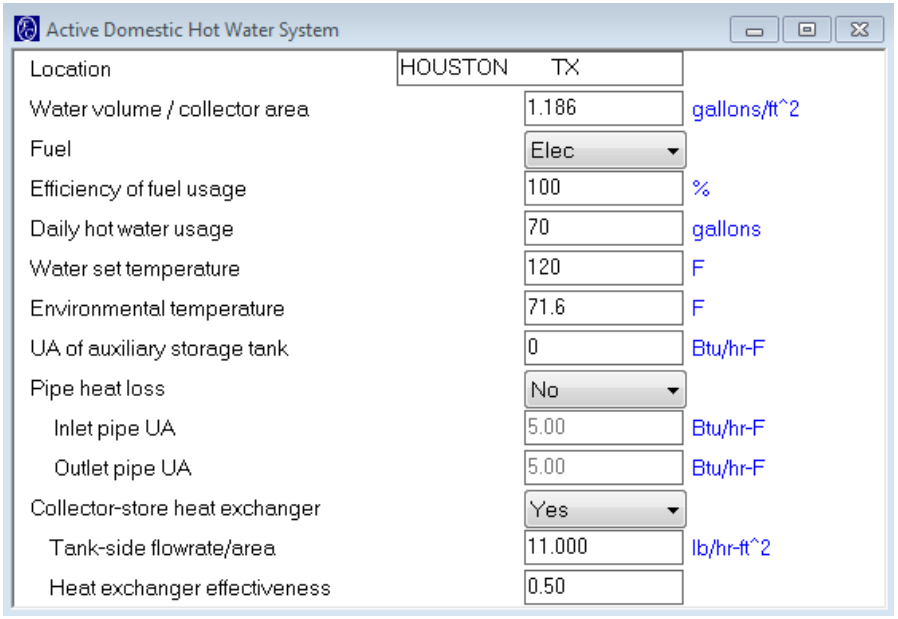


Figure 4-3 Active Domestic Hot Water System Input

Thermal Output

	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.214	0.958	0.454	0.526
Feb	2.268	0.862	0.345	0.599
Mar	2.914	0.949	0.262	0.723
Apr	2.970	0.911	0.198	0.783
May	3.241	0.936	0.152	0.838
Jun	3.320	0.901	0.101	0.888
Jul	3.341	0.929	0.106	0.886
Aug	3.350	0.929	0.103	0.889
Sep	3.151	0.903	0.129	0.857
Oct	3.182	0.942	0.168	0.822
Nov	2.529	0.918	0.301	0.672
Dec	2.005	0.954	0.519	0.456
Year	34.485	11.093	2.838	0.744

Figure 4-4 F-Chart Simulation-Base Case

4.3 TRNSYS Simulation

This section performs TRNSYS simulation for SDHW system. Figure 4-5 models the SDHW system by TRNSYS program that is used to simulate transient system. There are ten main components presented in the TRNSYS model, which are "Weather" (Type 15-2), "Collectors" (Type 1b), "Heat Exchanger" (Type 91), "Controller" (Type 2b), "Pump1&2" (Type 3d), "Pre-Heat Storage Tank" (Type 4a), "Auxiliary Heater" (Type 6), "Hot Water Demand" (Type 14b), "Mains Water Temp" (Type 14e) and "Load" (Type 6). In the following sections detail the settings for each TRNSYS component.

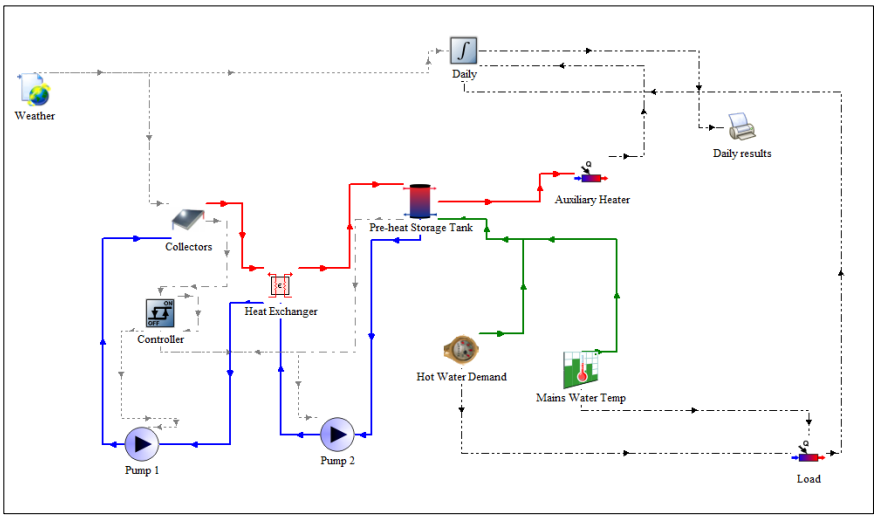


Figure 4-5 TRNSYS Simulation Model of SDHW System

4.3.1 Weather

The weather information is extracted from TMY2-Houston weather file by the help with component Type 15-2. Table 4-1shows the parameter input information for this component. The TMY2 Houston weather file is linked to “External Files” sections inside this component. The output data is properly linked to the component called “Collectors”, such as “Dry bulb temperature”, “Global horizontal radiation”, “Total diffuse radiation on the horizontal”, “Total titled surface radiation for surface”, “Angle of incidence for surface”, “Slope of surface” and “Ground reflectance”.

Table 4-1 Weather Input Summary

Parameter	Value	Unit	Remark
File Type	2	-	2=TMY2 format
Logical Unit	43	-	-
Tilted Surface Radiation Mode	3	-	3=Reindl Model
Ground Reflectance - no snow	0.2	-	
Ground Reflectance - snow	0.7	-	
Number of Surface	1	-	
Tracking Mode	1	-	1=Fixed sruface
Slope of Surface	29.8	degree	
Azimuth of Surface	0	degree	

4.3.2 Collectors

Collectors are modeled by Type 1b that is a quadratic efficiency collector with 2nd-order incidence angle modifier. Table 4-2 shows the parameter and input settings for this component. Its outlet temperature is linked to “Controller”. Both outlet temperature and outlet flow rate are linked to “Heat Exchanger”.

Table 4-2 Collectors Input Summary

Parameter	Value	Unit
Number in Series	1	
Collector Area	64.08	ft^2
Fluid Specific Heat	1	Btu/lb-F
Efficiency Mode	1	-
Tested Flow Rate	4.98	lb/hr-ft^2
Intercet Efficiency	0.694	-
Efficiency Slope	0.847	Btu/hr-ft^2-F
Efficiency Curvature	0	Any
Optical Mode	2	-
1st-Order IAM	0.25	-
2nd-Order IAM	0	-
Input	**Value**	**Unit**
Inlet Temperature	Linked	F
Inlet flow rate	Linked	Lb/hr
Ambient Temperature	71.6	F
Incident Radiation	Linked	Btu/hr-ft^2
Total Horizontal Radiation	Linked	Btu/hr-ft^2
Horizontal Diffuse Radiation	Linked	Btu/hr-ft^2
Ground refelctance	Linked	-
Incidence Angle	Linked	degree
Collector Slope	Linked	degree

4.3.3 Heat exchanger

Heat exchanger is modeled by Type 91 used to model constant heat effectiveness heat exchanger. In this case, the heat effectiveness is set to 0.5, shown in Table 4-3. The source-side outlet temperature and flow rate are linked to “Pump1” and load0side outlet temperature and flow rate are linked to “Pre-heat Storage Tank”.

Table 4-3 Heat Exchanger Input Summary

Parameter	Value	Unit
Heat Excahnger Effectiveness	0.5	-
Specific Heat of Source Side Fluid	1	Btu/lb-F
Specific Heat of Load Side Fluid	1	Btu/lb-F
Input	**Value**	**Unit**
Source Side Inlet Temperature	Linked	F
Source Side Flow Rate	Linked	lb/hr
Load Side Inlet Temperature	Linked	F
Load Side Flow Rate	Linked	lb/hr

4.3.4 Controller

A differential controlled Type 2b is used in this simulation. The high limit cut-off temperature is set to 212 F (100 C). By testing the temperature difference between the Pre-heat storage tank and collector outlet temperature, the input control function is decided either “0” or“1” to further control the “Pump1” and “Pump 2”. When control function equals to “0”, the pumps stop pumping the water while control function “1” drives the pumps to work. The detailed settings are shown in Table 4-4.

Table 4-4 Controller Input Summary

Parameter	Value	Unit
No. of Oscillations	5	-
High Limit Cut-Out	212	F
Input	**Value**	**Unit**
Upper Input Temperature Th	68	F
Lower Input Temperature Tl	50	F
Monitoring Temperature Tin	68	F
Input Control Function	0	-
Upper Dead Band dT	0	Temp.Difference
Lower Dead Band dT	0	Temp.Difference

4.3.5 Pumps

Pump 1 and Pump 2 are modeled by Type 3d which is a single speed pump. The pump control signal is linked to the controller. Table 4-5 summarizes the pump settings.

Table 4-5 Pump1&2 Input Summary

Parameter	Value	Unit
Maximum Flow Rate	704.9	lb/hr
Fluid Specific Heat	1	Btu/lb-F
Maximum Power	0.0625	hp
Convection Coefficient	0	-
Input	**Value**	**Unit**
Inlet Fluid Temperature	67.9	F
Inlet Mass Flow Rate	704.88	lb/hr
Control Signal	1	-

4.3.6 Pre-heat storage tank

The pre-heat storage tank is simulated by Type 4a classified as stratified storage tank. Fine nodes are assumed inside tank layers with 1.05 ft height each. The adiabatic tank model assumes no heat loss during the storage process. The tank volume is decided by formulae: water volume/collector area * total collector area. For the base case, the proximate tank volume is 76 gallons. The hot-side outlet temperature and flow rate are linked to auxiliary heater and code-side water is pumped back to heat exchanger. Detailed setting information is shown in Table 4-6.

Table 4-6 Pre-Heat Tank Input Summary

Parameter	Value	Unit
Fixed Inlet Positions	1	-
Tank Volume	76	Gal
Fluid Specific Heat	1	Btu/lb-F
Fluid Density	62.4	lbm/ft^3
Tank Loss Coefficient	0	Btu/hr ft^2 F
Height of Node-1	1.05	ft
Height of Node-2	1.05	ft
Height of Node-3	1.05	ft
Height of Node-4	1.05	ft
Height of Node-5	1.05	ft
Auxiliary Heater Mode	1	-
Boiling Point	212	F
		Unit
Hot-Side Temperature	Linked	F
Hot-Side Flow rate	Linked	lb/hr
Cold-Side Temperature	Linked	F
Cold-Side Flow rate	Linked	lb/hr
Environment Temperature	71.6	F

4.3.7 Auxiliary and load heaters

The heaters are modeled by Type 6, assuming no heat loss during heating operation. All the water coming out of pre-heat storage tanks are designed to be heated up till set point temperature 120 F. The parameter and input values are set up, shown in Table 4-7.

Table 4-7 Auxiliary and Load Heaters Input Summary

Parameter	Value	Unit
Maximum Heating Rate	23	kW
Specific Heat of Fluid	1	Btu/lb-F
Overall Loass Coefficient for Heating Operation	0	Btu/hr-F
Efficient of Auxiliary Heater	1	-
Input	**Value**	**Unit**
Inlet Fluid Temperature	Linked	F
Fluid Mass Flow Rate	Linked	lb/hr
Control Function	1	-
Set Point Temperature	120	F
Temperature of Surroundings	71.6	F

4.3.8 Hot water demand

The hourly hot water draw profile setting is based on ASHRAE Standard 90.2-2007. The daily hot water demand is 70 gallons/day, which is converted into SI hourly demand values in Figure 4-6. It has been noticed that this general hot water draw profile shows not only daily demand but also the night demand. In F-Chart simulation, there is no water profile having been considered. Therefore, the comparisons will show the differences because of this profile assumption.

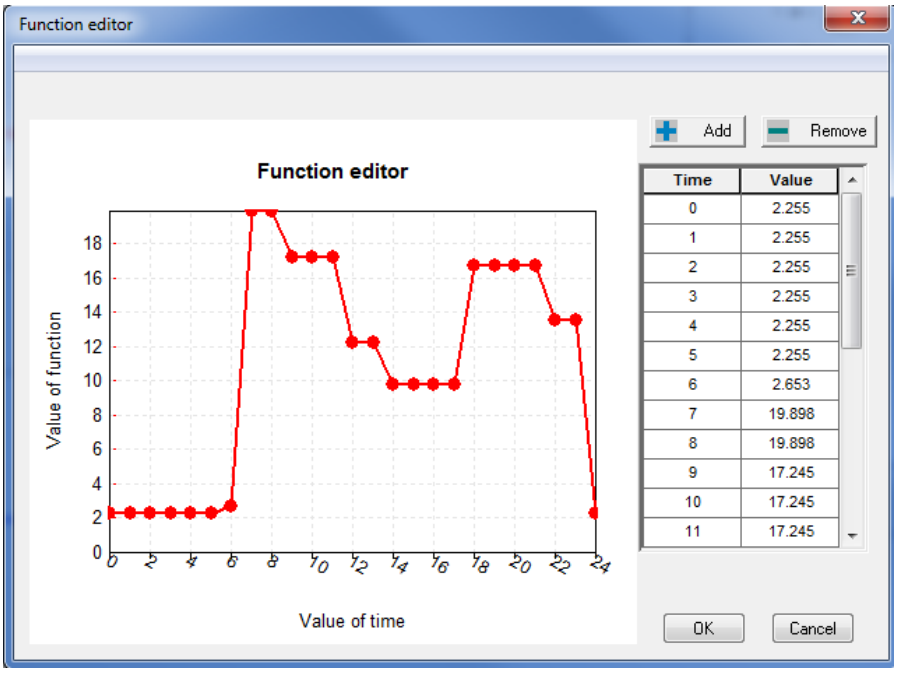


Figure 4-6 Converted Hot Water Draw Profile in SI Unit (kg/hr)

Table 4-8 Hot Water Draw Profile from ASHRAE 90.2-2007

Hour	Fraction of Daily Hot Water Draw
1	0.0085
2	0.0085
3	0.0085
4	0.0085
5	0.0085
6	0.01
7	0.075
8	0.075
9	0.065
10	0.065
11	0.065
12	0.046
13	0.046
14	0.037
15	0.037
16	0.037
17	0.037
18	0.063
19	0.063
20	0.063
21	0.063
22	0.051
23	0.051
24	0.0085

4.3.9 Mains water temperature

Mains Water temperature is input with the help of Type 14e. The settings refer to the temperatures in F-Chart weather file, varying each month, seen in Figure 4-7.

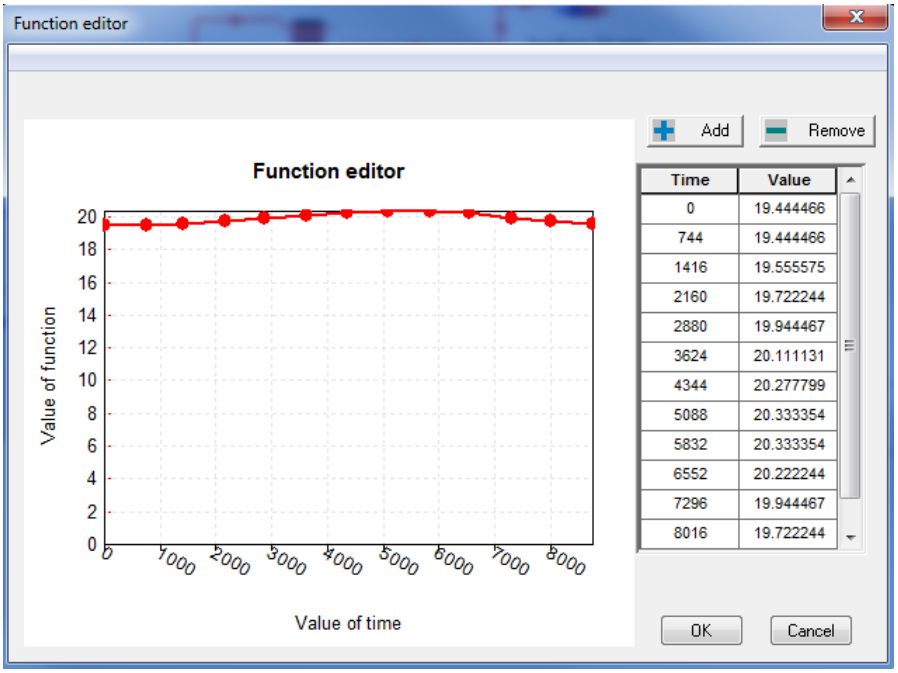


Figure 4-7 Mains Water Temperature in SI Unit

4.3.10 SDHW system simulation comparisons of base case: TRNSYS v.s. F-Chart

In TRNSYS simulation, the user is allowed to input very small time interval for the simulation. In this case, 1 hr simulation time interval is adopted.

Figure 4-8 - Figure 4-11 detail the simulation comparisons for SDHW system by TRNSYS and F-Chart in the aspect of Solar, Dhw, Aux and f factor. It is noticed that the same patterns have been found.

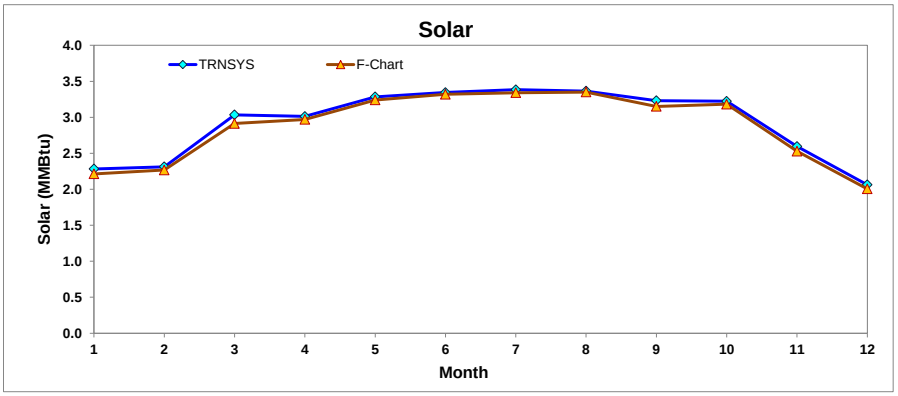


Figure 4-8 Monthly Total Solar Radiation Incident on the Collector Surface (time step=1 hr).

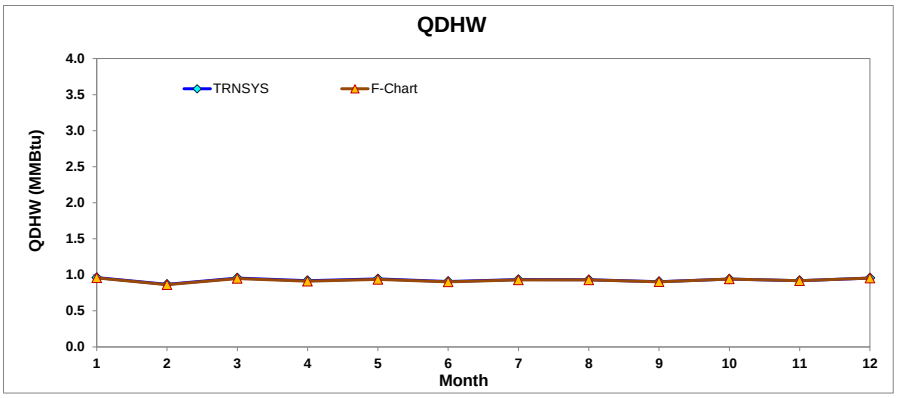


Figure 4-9Monthly Total Water Heating Demand (time step=1 hr).

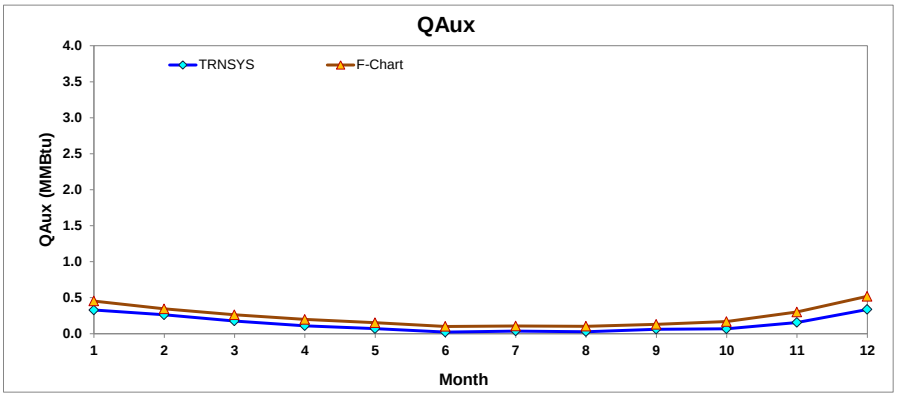


Figure 4-10Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand (time step=1 hr).

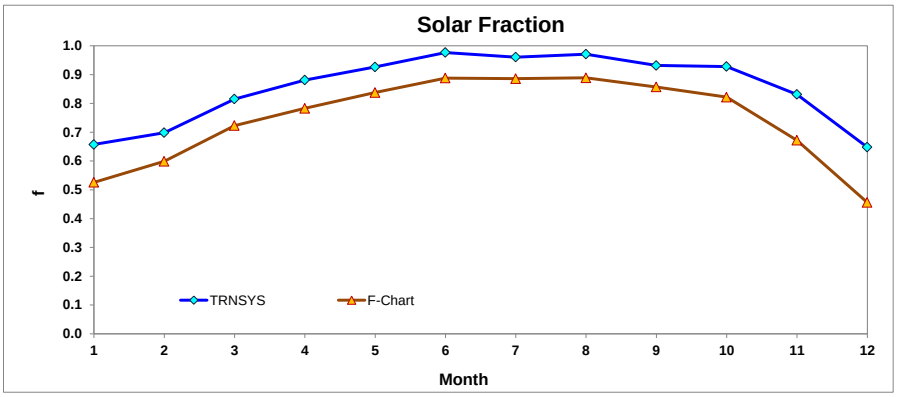


Figure 4-11Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System (time step=1 hr).

In Table 4-9, TRNSYS predicted more useful solar that has been used in the system to provide daily hot water demand. Both “Solar” and “Dhw” match very well with difference

percentage (F-Chart-TRNSYS/F-Chart), -1.9% and 0.4, respectively, compared to F-Chart simulation. The auxiliary heating has a larger percentage difference, 41.9%, which results in larger difference percentage of f factor comparisons, -14.5%.

Table 4-9 Comparisons Data between TRNSYS and F-Chart (time step=1 hr)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.282	0.961	0.329	0.658	2.214	0.958	0.454	0.526	-3.1%	-0.3%	27.5%	-25.0%
Feb	2.313	0.867	0.262	0.698	2.268	0.862	0.345	0.599	-2.0%	0.6%	24.2%	-16.6%
Mar	3.035	0.955	0.176	0.815	2.914	0.949	0.262	0.723	-4.1%	0.7%	32.7%	-12.8%
Apr	3.012	0.918	0.109	0.881	2.970	0.911	0.198	0.783	-1.4%	0.8%	44.9%	-12.5%
May	3.285	0.943	0.069	0.927	3.241	0.936	0.152	0.838	-1.3%	0.7%	54.5%	-10.6%
Jun	3.344	0.907	0.021	0.977	3.320	0.901	0.101	0.888	-0.7%	0.7%	79.2%	-10.0%
Jul	3.384	0.934	0.037	0.961	3.341	0.929	0.106	0.886	-1.3%	0.5%	65.5%	-8.5%
Aug	3.364	0.931	0.027	0.971	3.350	0.929	0.103	0.889	-0.4%	0.3%	73.9%	-9.2%
Sep	3.231	0.904	0.062	0.932	3.151	0.903	0.129	0.857	-2.5%	0.2%	52.3%	-8.7%
Oct	3.224	0.941	0.068	0.928	3.182	0.942	0.168	0.822	-1.3%	0.1%	59.7%	-12.9%
Nov	2.595	0.918	0.155	0.831	2.529	0.918	0.301	0.672	-2.6%	0.0%	48.5%	-23.7%
Dec	2.062	0.955	0.336	0.648	2.005	0.954	0.519	0.456	-2.8%	0.1%	35.2%	-42.1%
Year	35.131	11.136	1.650	0.852	34.485	11.093	2.838	0.744	-1.9%	0.4%	41.9%	-14.5%

4.4 Discussion

During the whole simulation process, it has been found that during the first several months the simulations results have some fluctuations due to the operation period. It takes time for the whole system to adjust its operating status and output the results. Thereby, two years simulation has been performed. The second year data is used to compare to F-Chart.

Figure 4-12 shows the hourly plots for Solar, Dhw and Aux from simulation time 8000-10000 hr. This demonstrates the base case simulation is reasonable. For example, when solar radiation during the daytime is low, the required auxiliary heating increases.

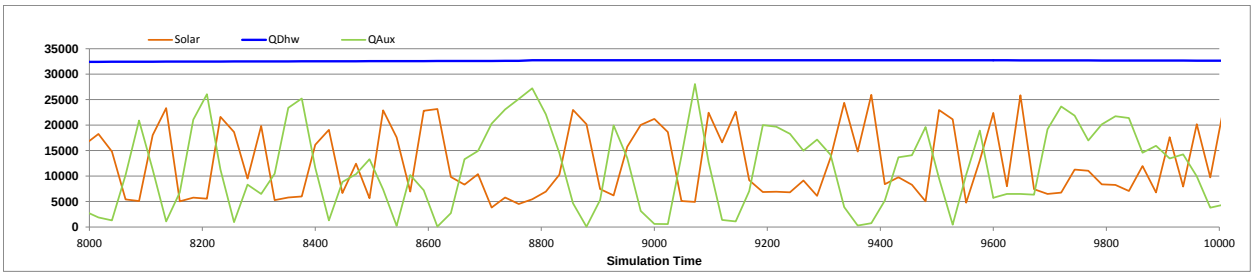


Figure 4-12Hourly Simulation of SDHW System-Base Case

5 SOLAR DOMESTIC HOT WATER SYSTEM SIMULATION COMPARISONS OF ANALYSIS 1 – WATER VOLUME/COLLECTOR AREA RATIO STUDY PART I

5.1 Overview

Starting from this section, different case studies are performed to further checking the simulation accuracy of TRNSYS program on SDHW System. This section will vary the total collector area from 64.02 ft^2 to 80 ft^2. With 80ft^2 total solar collector area, the water volume/collector area ratio is varied by 0.93,3, 5.9 and 7.3. This means the pre-heat storage tank volumes are varied to 74.4,240,472 and 584 gallons. The other settings are kept as the same as base case.

5.2 Analysis 1-Ratio=0.93

When ratio equals to 0.93, the storage tank volume is 74.4 gallons. The total collector area is 80 ft^2 and daily hot water usage is still 70 gallons/day.

5.2.1 F-Chart simulation

Figure 5-1 and Figure 5-2 show the input information for F-Chart. The changed settings are presented in a red box. Figure 5-3 gives the result summary of modified simulation.

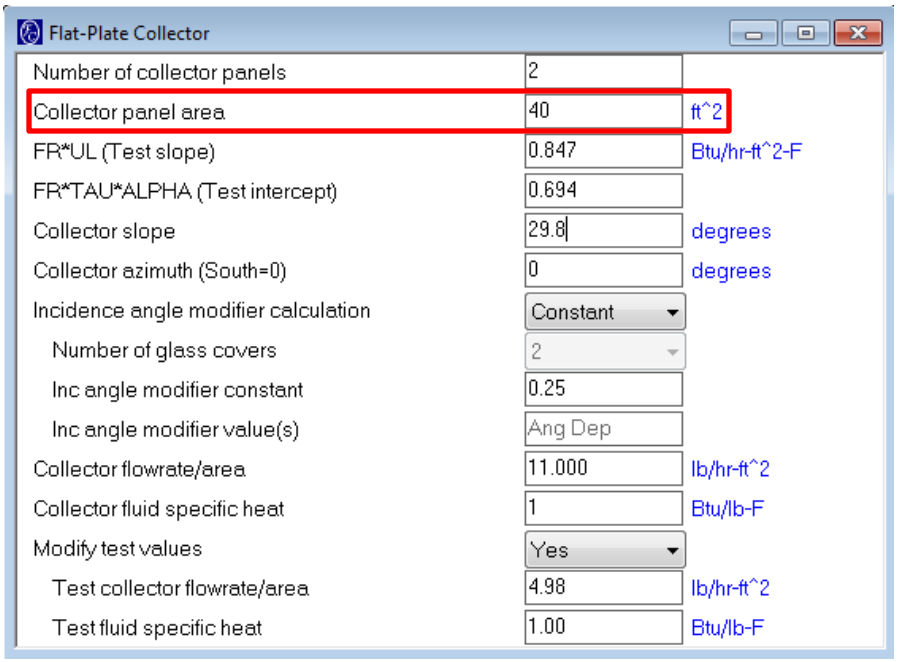


Figure 5-1 Flat-Plate Collector Input

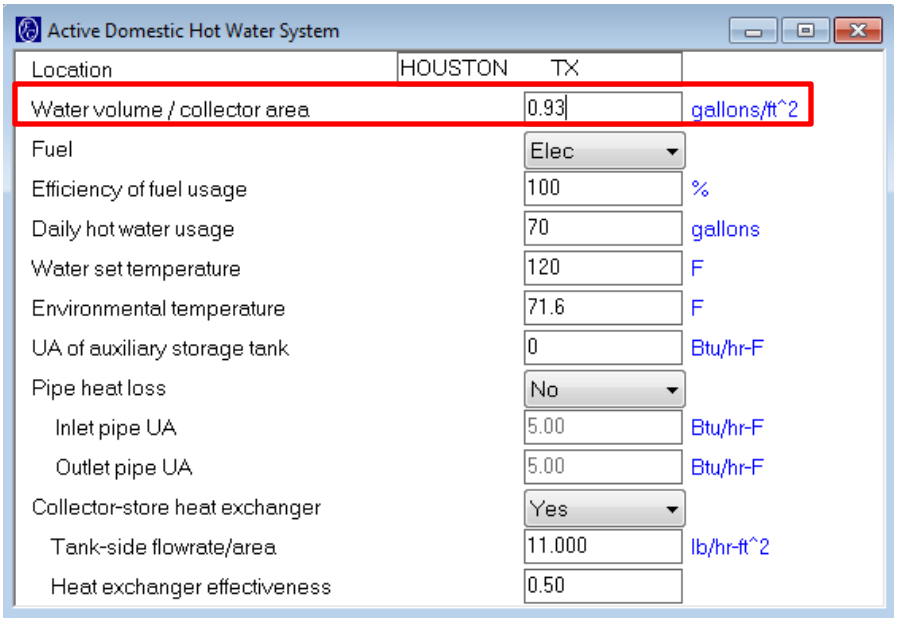
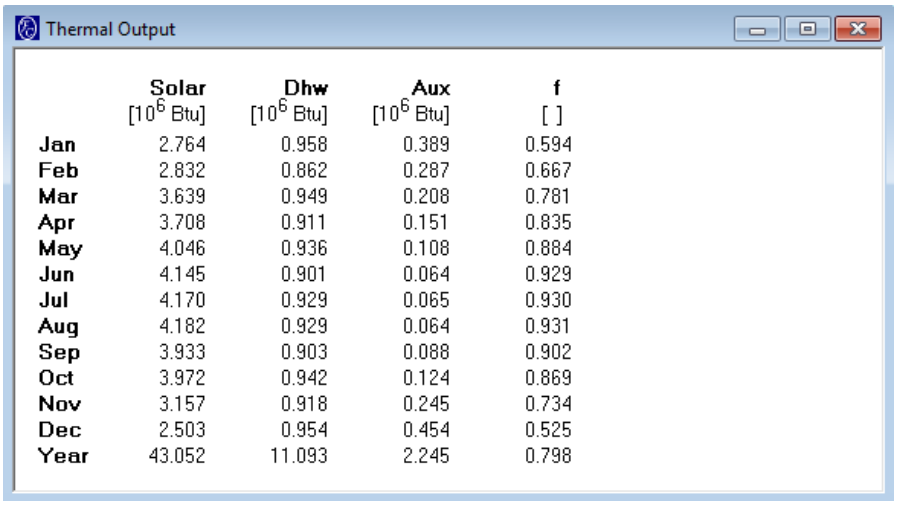


Figure 5-2 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	0.958	0.389	0.594
Feb	2.832	0.862	0.287	0.667
Mar	3.639	0.949	0.208	0.781
Apr	3.708	0.911	0.151	0.835
May	4.046	0.936	0.108	0.884
Jun	4.145	0.901	0.064	0.929
Jul	4.170	0.929	0.065	0.930
Aug	4.182	0.929	0.064	0.931
Sep	3.933	0.903	0.088	0.902
Oct	3.972	0.942	0.124	0.869
Nov	3.157	0.918	0.245	0.734
Dec	2.503	0.954	0.454	0.525
Year	43.052	11.093	2.245	0.798

Figure 5-3 F-Chart Simulation

5.2.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 5-4 and Figure 5-5.

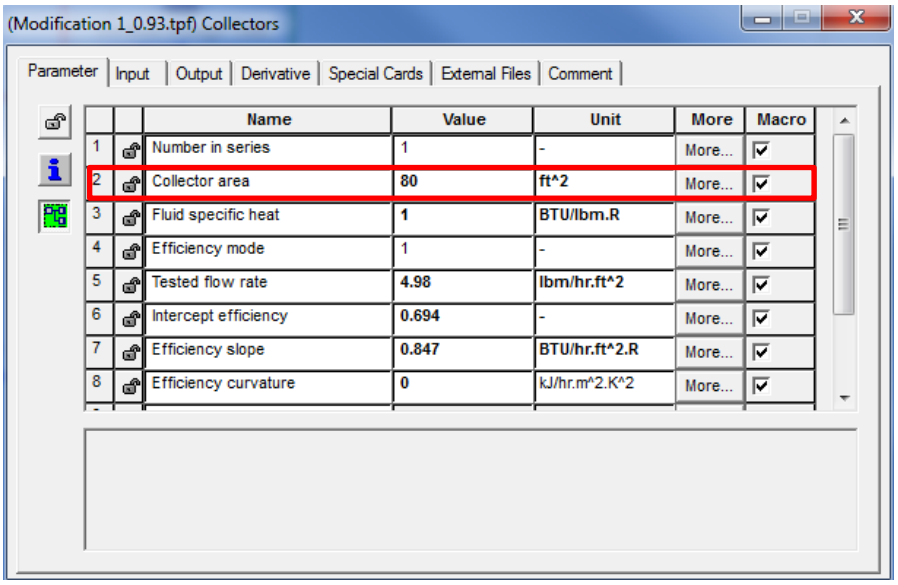


Figure 5-4 TRNSYS Component “Collectors” Settings

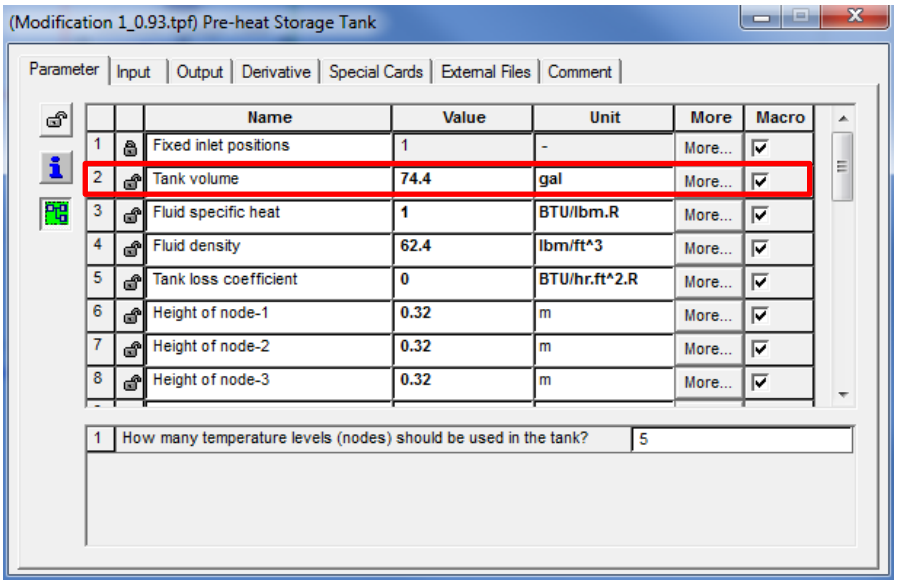


Figure 5-5 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 5-6 -Figure 5-9 present the simulation comparisons for ANALYSIS 1 (ratio=0.93) including Solar, Dhw, Aux and f factor. In

Table **5-1**, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 39% and -9.9 %, respectively.

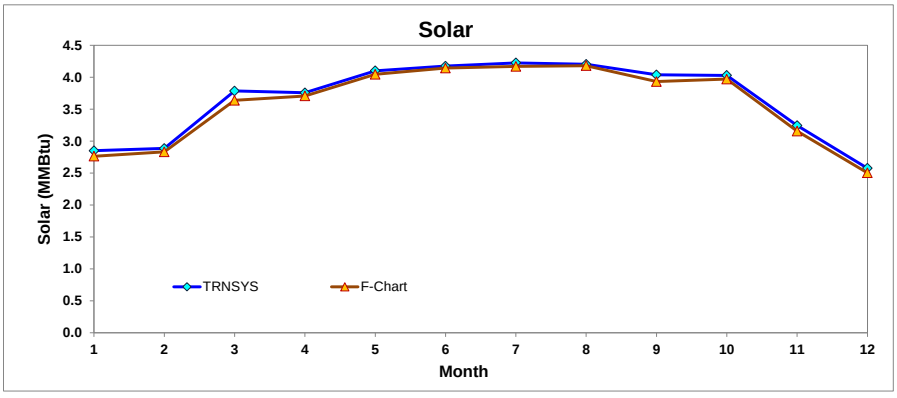


Figure 5-6 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 1 (Ratio=0.93)

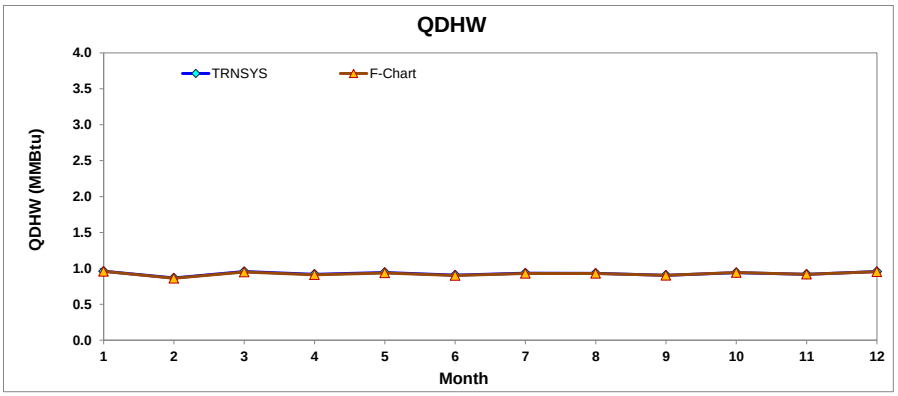


Figure 5-7Monthly Total Water Heating Demand -ANALYSIS 1 (Ratio=0.93)

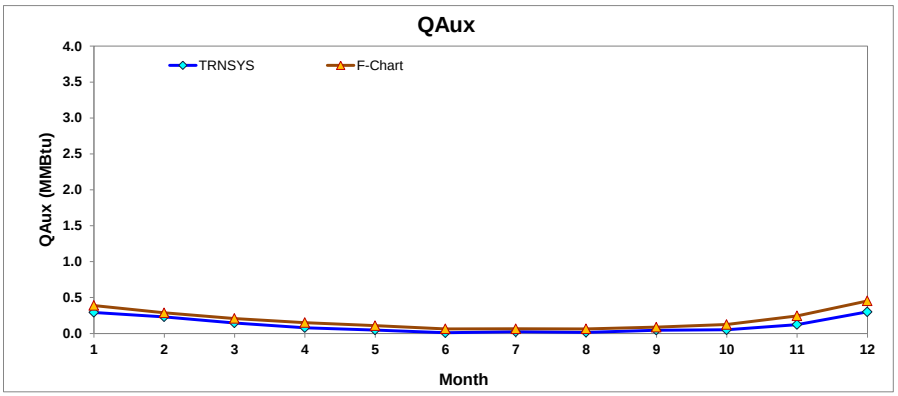


Figure 5-8Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 1 (Ratio=0.93)

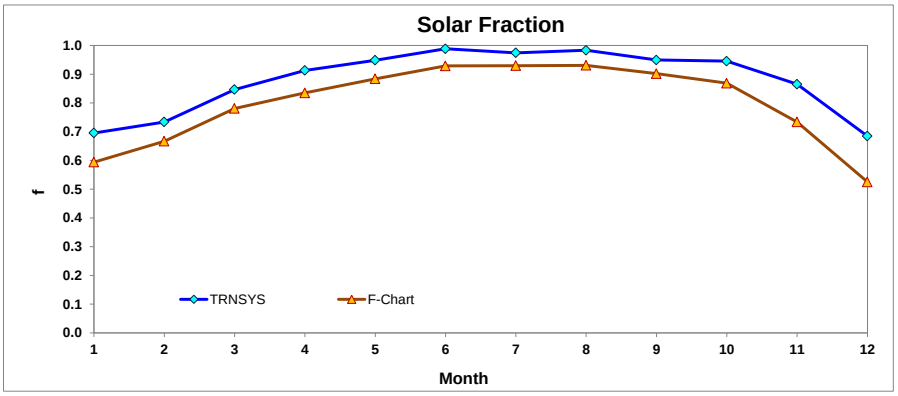


Figure 5-9Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 1 (Ratio=0.93)

Table 5-1 Comparisons Data between TRNSYS and F-Chart ANALYSIS 1 (Ratio=0.93)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	0.961	0.293	0.695	2.764	0.958	0.389	0.594	-3.1%	-0.3%	24.8%	-17.1%
Feb	2.886	0.867	0.231	0.734	2.832	0.862	0.287	0.667	-1.9%	0.6%	19.7%	-10.0%
Mar	3.786	0.955	0.146	0.847	3.639	0.949	0.208	0.781	-4.0%	0.7%	29.6%	-8.4%
Apr	3.757	0.918	0.080	0.913	3.708	0.911	0.151	0.835	-1.3%	0.8%	47.2%	-9.4%
May	4.101	0.943	0.048	0.949	4.046	0.936	0.108	0.884	-1.4%	0.7%	55.3%	-7.3%
Jun	4.175	0.907	0.010	0.989	4.145	0.901	0.064	0.929	-0.7%	0.7%	83.7%	-6.4%
Jul	4.226	0.934	0.024	0.975	4.170	0.929	0.065	0.930	-1.3%	0.5%	63.5%	-4.8%
Aug	4.203	0.931	0.015	0.983	4.182	0.929	0.064	0.931	-0.5%	0.3%	75.8%	-5.6%
Sep	4.039	0.904	0.046	0.950	3.933	0.903	0.088	0.902	-2.7%	0.2%	48.1%	-5.3%
Oct	4.030	0.941	0.051	0.946	3.972	0.942	0.124	0.869	-1.5%	0.1%	58.8%	-8.8%
Nov	3.245	0.918	0.124	0.865	3.157	0.918	0.245	0.734	-2.8%	0.0%	49.6%	-17.9%
Dec	2.575	0.955	0.301	0.685	2.503	0.954	0.454	0.525	-2.9%	0.1%	33.6%	-30.4%
Year	43.873	11.136	1.369	0.877	43.052	11.093	2.245	0.798	-1.9%	0.4%	39.0%	-9.9%

5.3 Analysis 1-Ratio=3

When ratio equals to 3, the storage tank volume is 240 gallons. The total collector area is 80 ft^2 and daily hot water usage is still 70 gallons/day.

5.3.1 F-Chart simulation

Figure 5-10 and Figure 5-11 show the input information for F-Chart. The changed settings are presented in a red box. Figure 5-12 gives the result summary of modified simulation.

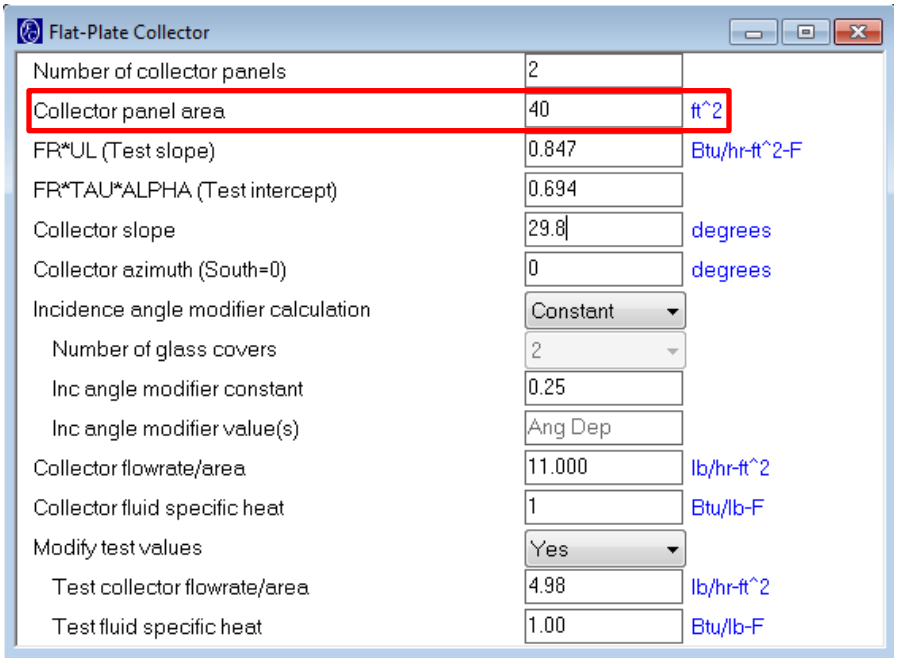


Figure 5-10 Flat-Plate Collector Input

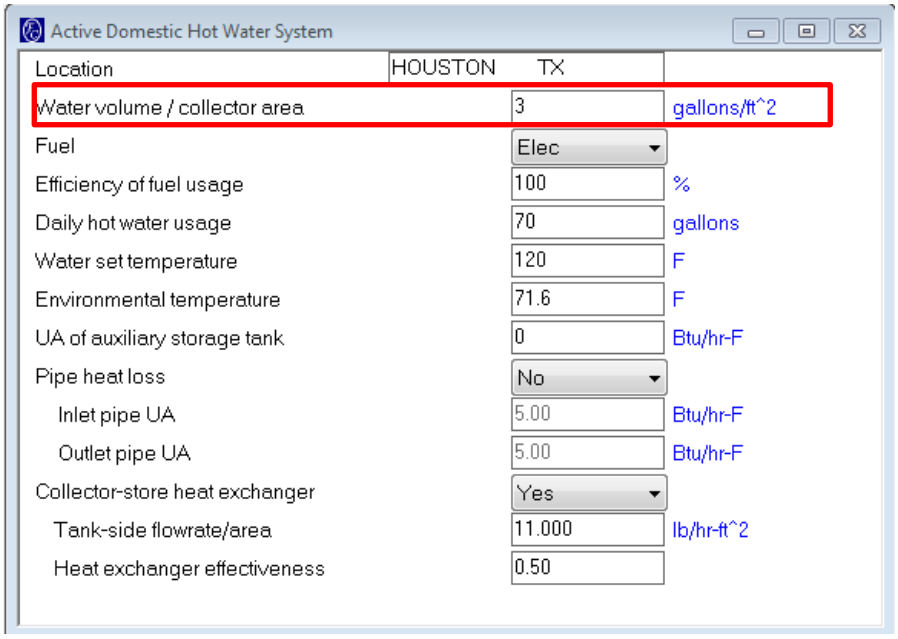
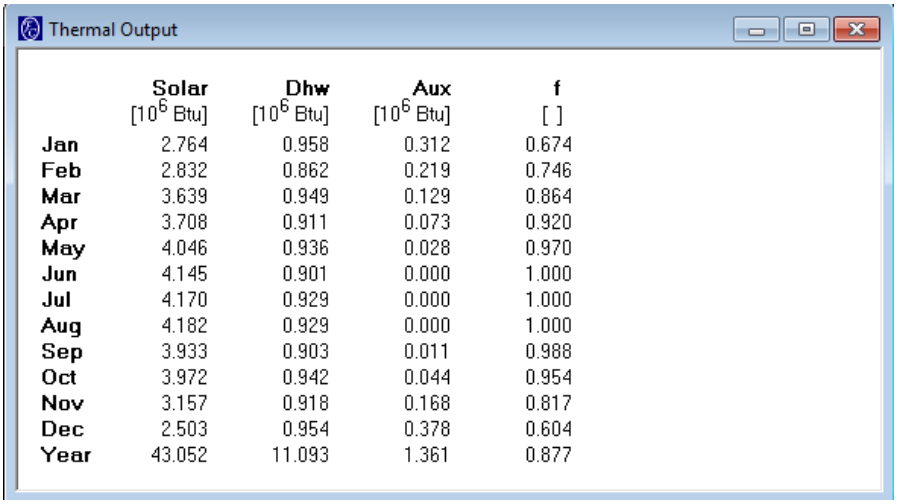


Figure 5-11 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	0.958	0.312	0.674
Feb	2.832	0.862	0.219	0.746
Mar	3.639	0.949	0.129	0.864
Apr	3.708	0.911	0.073	0.920
May	4.046	0.936	0.028	0.970
Jun	4.145	0.901	0.000	1.000
Jul	4.170	0.929	0.000	1.000
Aug	4.182	0.929	0.000	1.000
Sep	3.933	0.903	0.011	0.988
Oct	3.972	0.942	0.044	0.954
Nov	3.157	0.918	0.168	0.817
Dec	2.503	0.954	0.378	0.604
Year	43.052	11.093	1.361	0.877

Figure 5-12 F-Chart Simulation

5.3.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 5-13 and Figure 5-14.

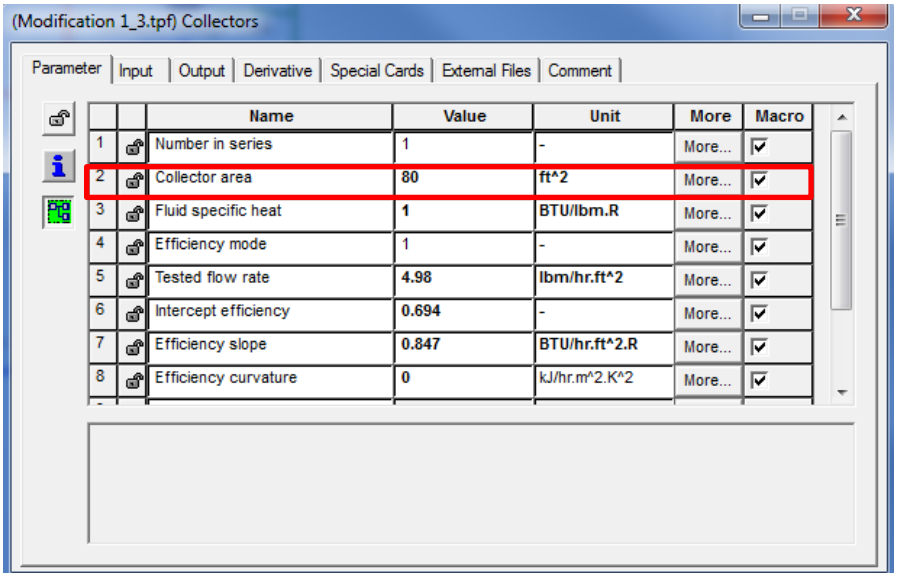


Figure 5-13 TRNSYS Component "Collectors" Settings

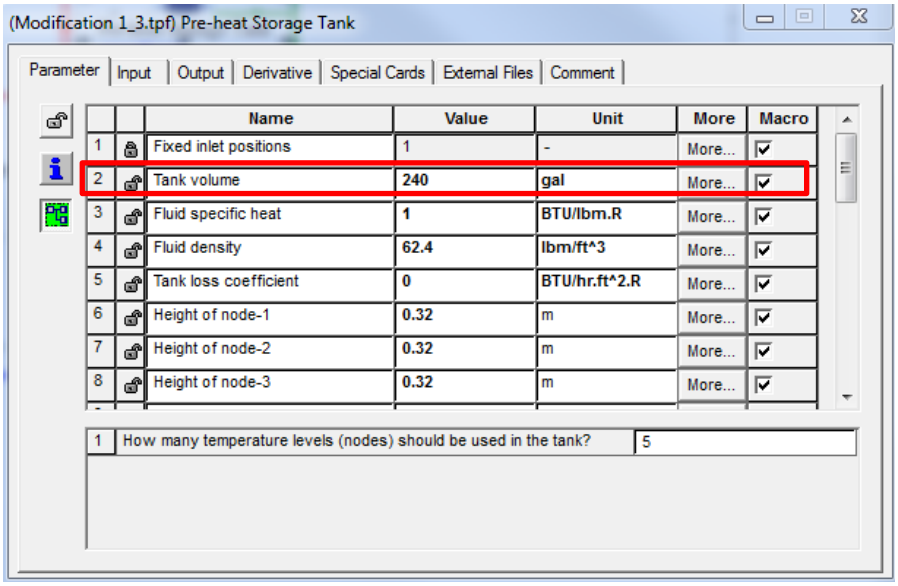


Figure 5-14 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 5-15-Figure 5-18 present the simulation comparisons for ANALYSIS 1 (ratio=3) including Solar, Dhw, Aux and f factor. In Table 5-2, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 52.4% and -7.4 %, respectively.

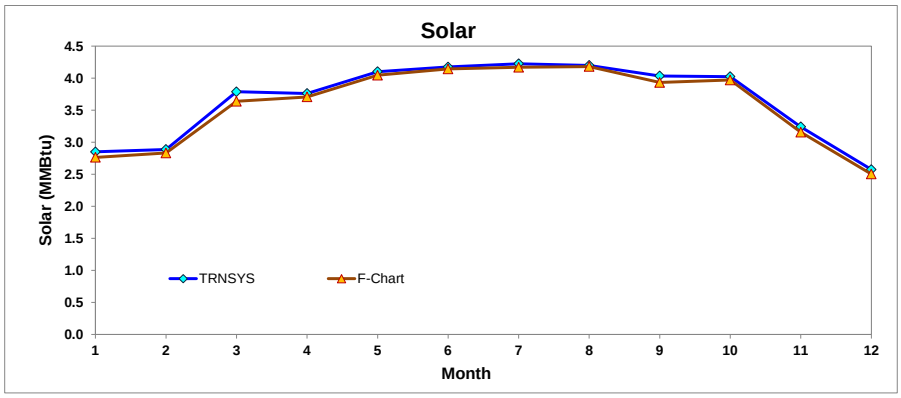


Figure 5-15 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 1 (Ratio=3)

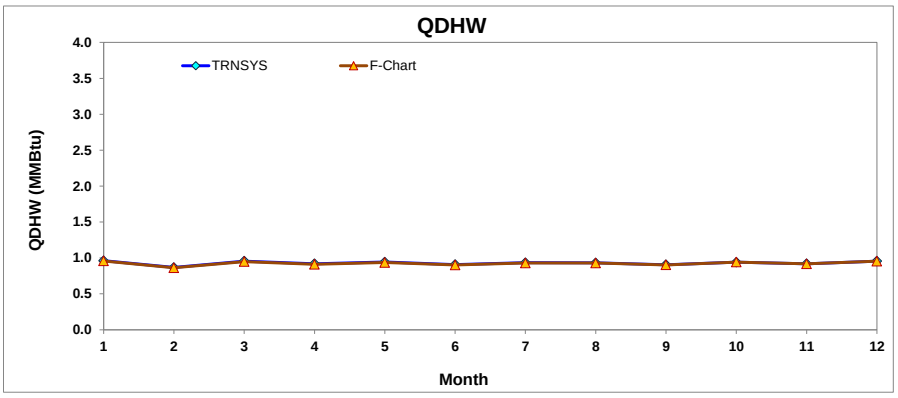


Figure 5-16Monthly Total Water Heating Demand -ANALYSIS 1 (Ratio=3)

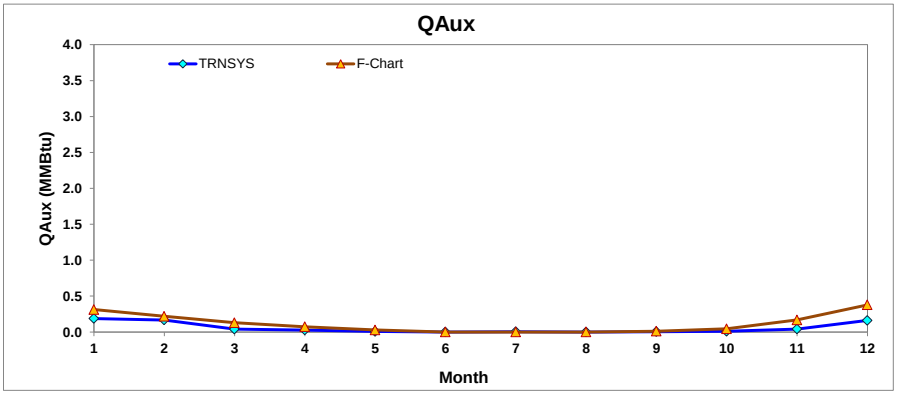


Figure 5-17Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 1 (Ratio=3)

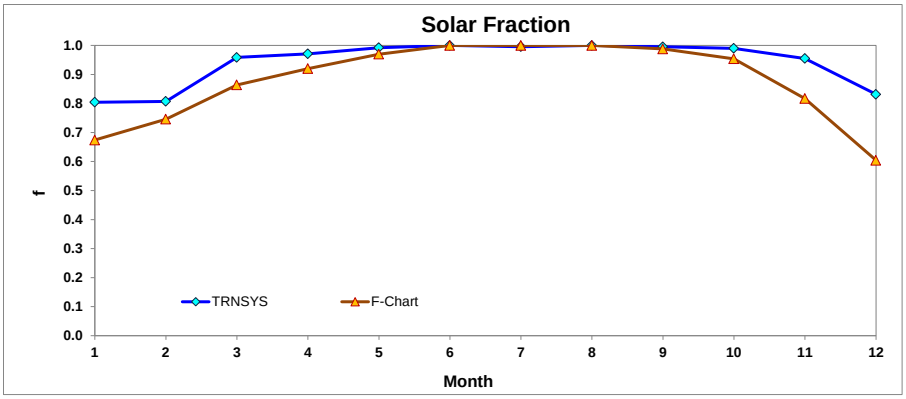


Figure 5-18Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 1 (Ratio=3)

Table 5-2 Comparisons Data between TRNSYS and F-Chart ANALYSIS 1 (Ratio=3)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	0.961	0.188	0.804	2.764	0.958	0.312	0.674	-3.1%	-0.3%	39.7%	-19.3%
Feb	2.888	0.867	0.167	0.807	2.832	0.862	0.219	0.746	-2.0%	0.6%	23.7%	-8.2%
Mar	3.789	0.955	0.039	0.959	3.639	0.949	0.129	0.864	-4.1%	0.7%	69.4%	-11.0%
Apr	3.762	0.918	0.027	0.971	3.708	0.911	0.073	0.920	-1.4%	0.8%	63.6%	-5.6%
May	4.101	0.943	0.007	0.992	4.046	0.936	0.028	0.970	-1.4%	0.7%	73.8%	-2.3%
Jun	4.176	0.907	0.000	1.000	4.145	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	4.225	0.934	0.004	0.996	4.170	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.4%
Aug	4.200	0.931	0.000	1.000	4.182	0.929	0.000	1.000	-0.4%	0.3%	N/A	0.0%
Sep	4.035	0.904	0.004	0.995	3.933	0.903	0.011	0.988	-2.6%	0.2%	62.3%	-0.8%
Oct	4.025	0.941	0.009	0.990	3.972	0.942	0.044	0.954	-1.3%	0.1%	78.7%	-3.8%
Nov	3.241	0.918	0.041	0.955	3.157	0.918	0.168	0.817	-2.7%	0.0%	75.4%	-16.9%
Dec	2.575	0.955	0.161	0.832	2.503	0.954	0.378	0.604	-2.9%	0.1%	57.5%	-37.7%
Year	43.866	11.136	0.648	0.942	43.052	11.093	1.361	0.877	-1.9%	0.4%	52.4%	-7.4%

5.4 Analysis 1-Ratio=5.9

When ratio equals to 5.9, the storage tank volume is 472 gallons. The total collector area is 80 ft^2 and daily hot water usage is still 70 gallons/day.

5.4.1 F-Chart simulation

Figure 5-19 and Figure 5-20 show the input information for F-Chart. The changed settings are presented in a red box. Figure 5-21 gives the result summary of modified simulation.

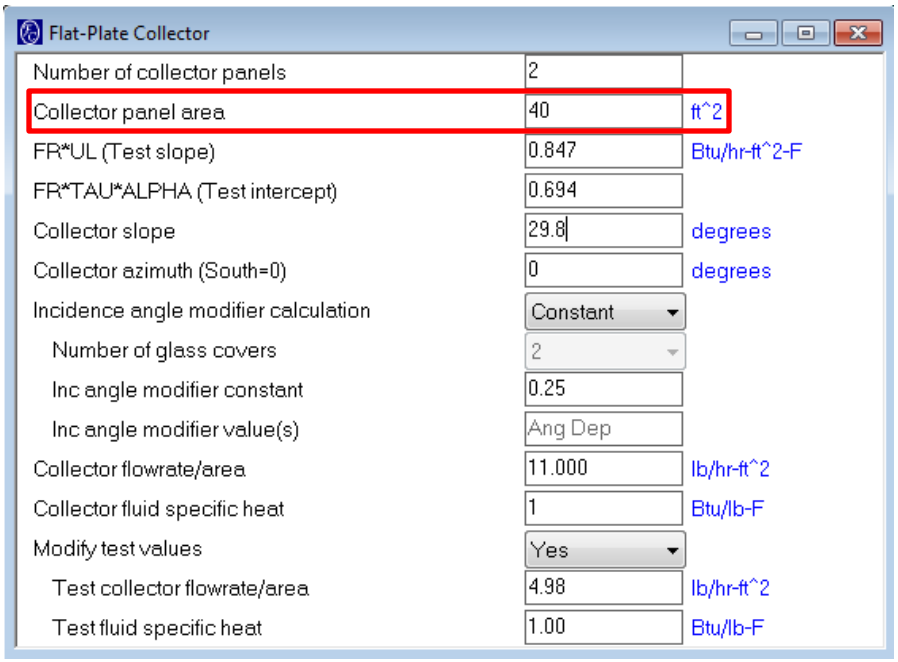


Figure 5-19 Flat-Plate Collector Input

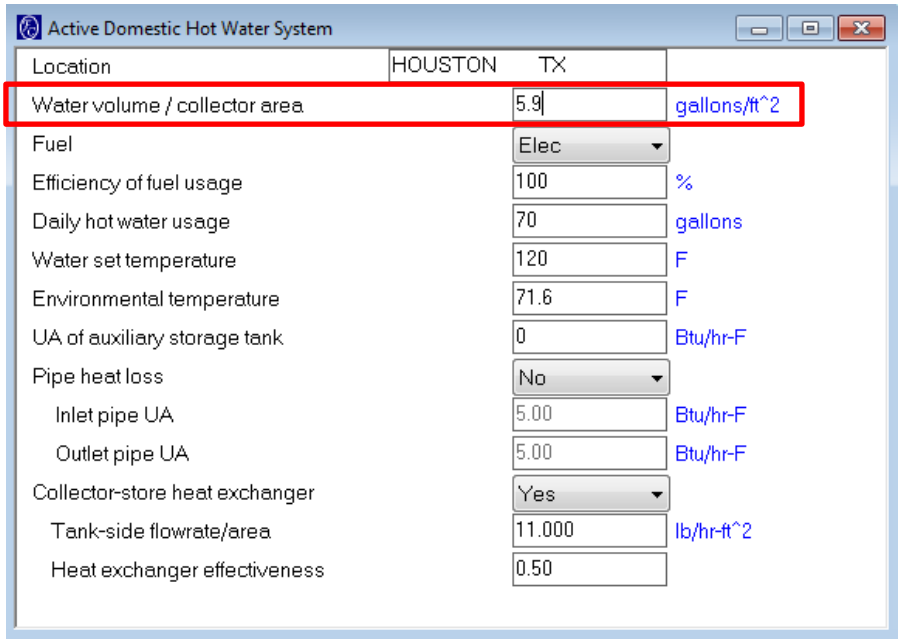
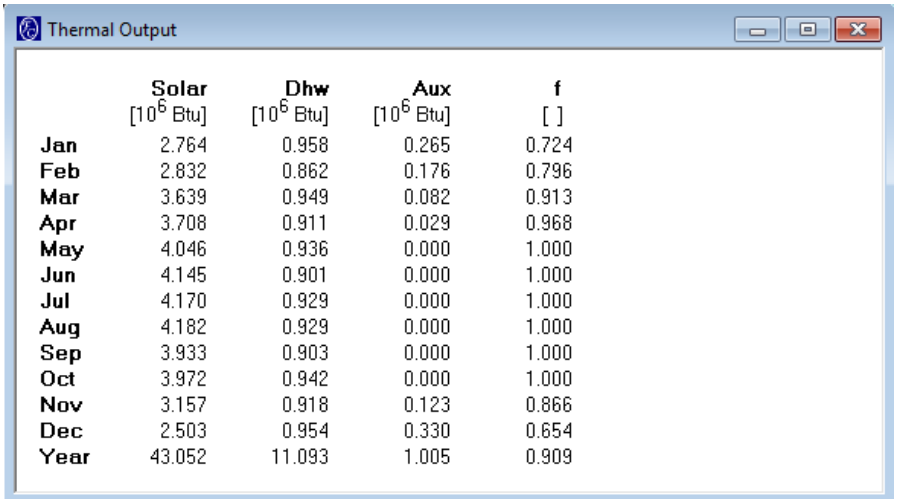


Figure 5-20 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	0.958	0.265	0.724
Feb	2.832	0.862	0.176	0.796
Mar	3.639	0.949	0.082	0.913
Apr	3.708	0.911	0.029	0.968
May	4.046	0.936	0.000	1.000
Jun	4.145	0.901	0.000	1.000
Jul	4.170	0.929	0.000	1.000
Aug	4.182	0.929	0.000	1.000
Sep	3.933	0.903	0.000	1.000
Oct	3.972	0.942	0.000	1.000
Nov	3.157	0.918	0.123	0.866
Dec	2.503	0.954	0.330	0.654
Year	43.052	11.093	1.005	0.909

Figure 5-21 F-Chart Simulation

5.4.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 5-22 and Figure 5-23.

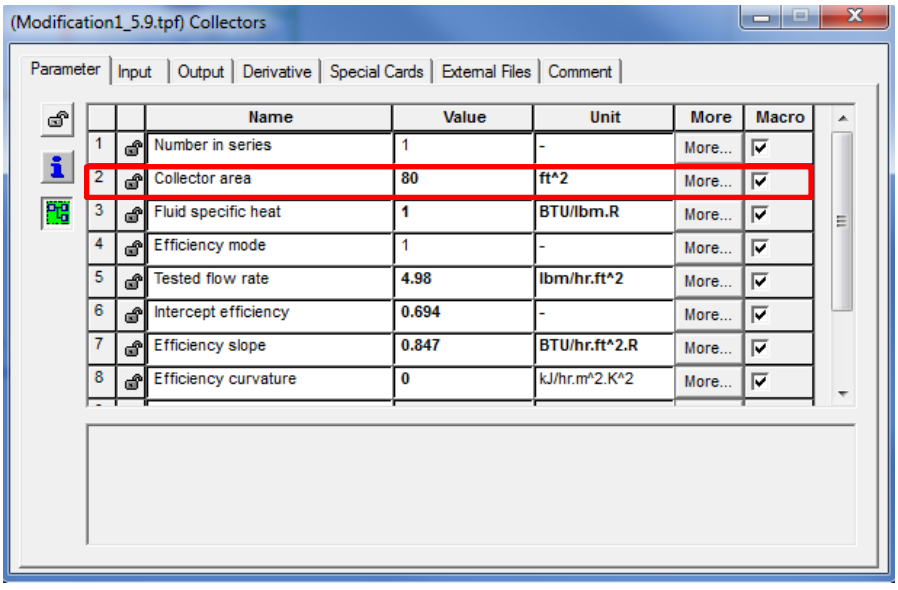


Figure 5-22 TRNSYS Component “Collectors” Settings

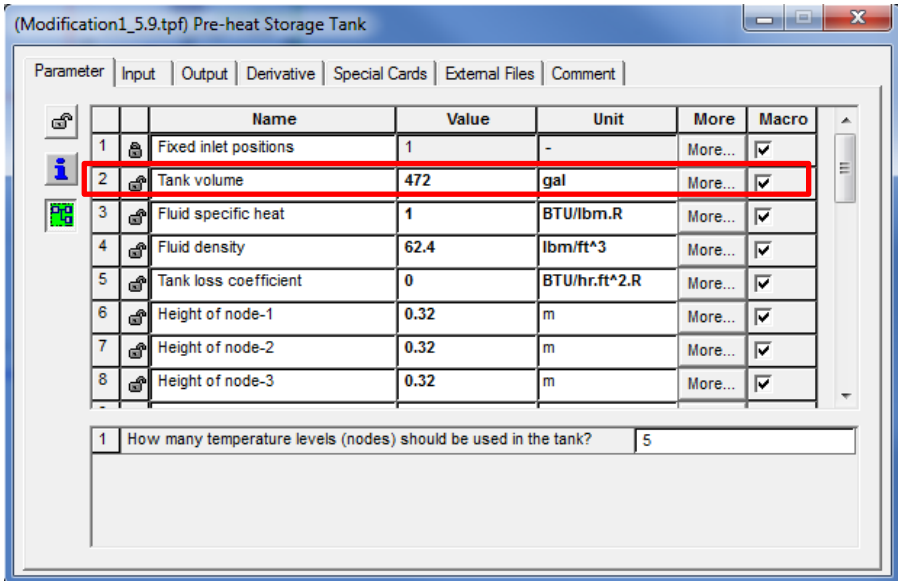


Figure 5-23 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 5-24-Figure 5-27 present the simulation comparisons for ANALYSIS 1 (ratio=5.9) including Solar, Dhw, Aux and f factor. In Table 5-3, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 56.8% and -5.7%, respectively.

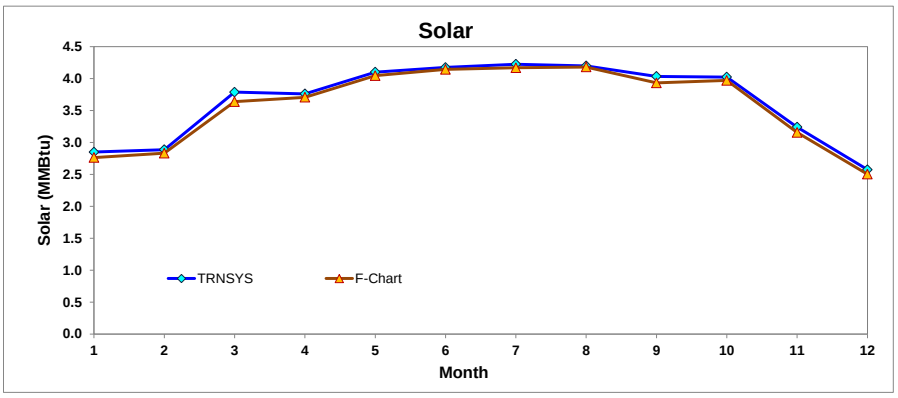


Figure 5-24 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 1 (Ratio=5.9)

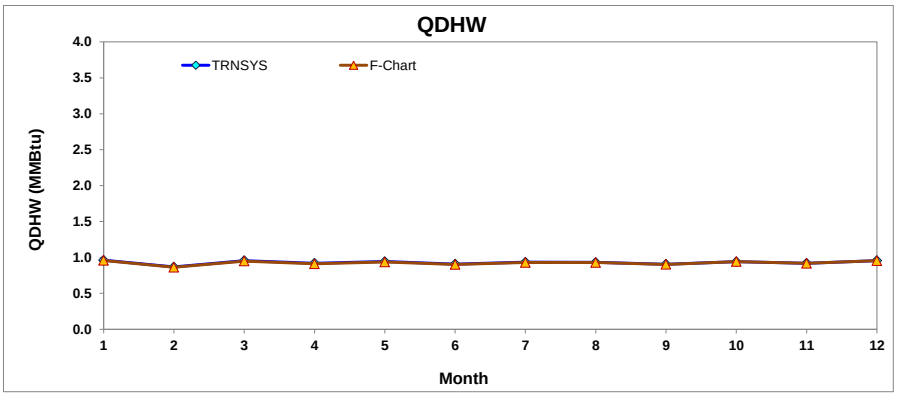


Figure 5-25Monthly Total Water Heating Demand -ANALYSIS 1 (Ratio=5.9)

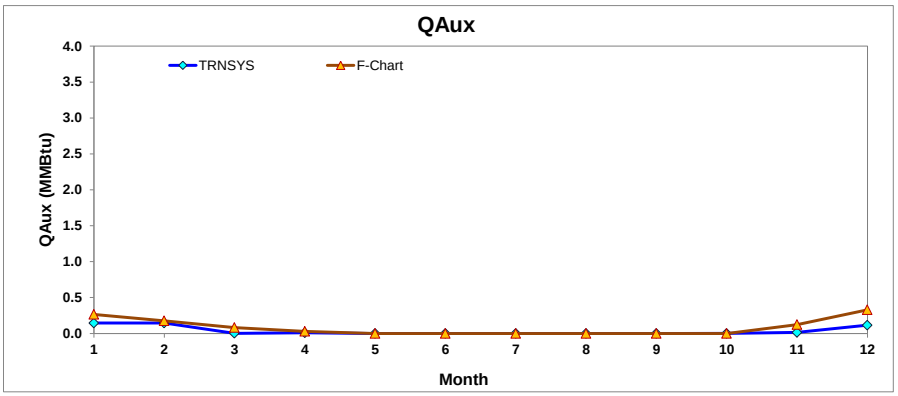


Figure 5-26Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 1 (Ratio=5.9)

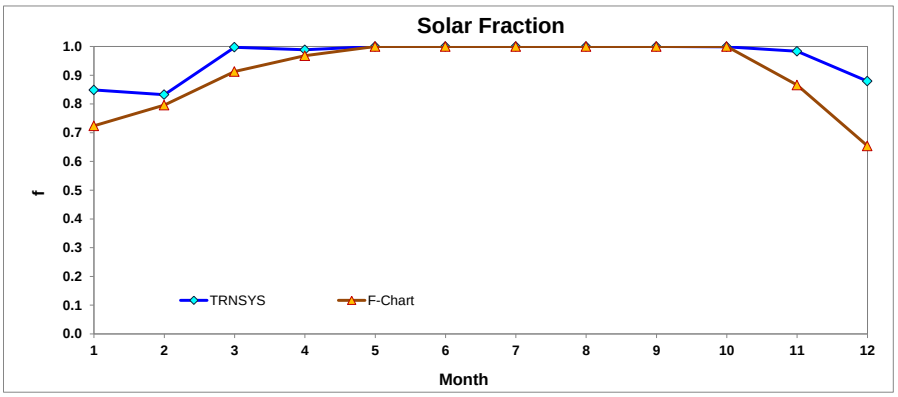


Figure 5-27Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 1 (Ratio=5.9)

Table 5-3 Comparisons Data between TRNSYS and F-Chart ANALYSIS 1 (Ratio=5.9)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	0.961	0.145	0.849	2.764	0.958	0.265	0.724	-3.1%	-0.3%	45.2%	-17.2%
Feb	2.888	0.867	0.145	0.832	2.832	0.862	0.176	0.796	-2.0%	0.6%	17.4%	-4.6%
Mar	3.789	0.955	0.002	0.998	3.639	0.949	0.082	0.913	-4.1%	0.7%	97.2%	-9.3%
Apr	3.762	0.918	0.010	0.989	3.708	0.911	0.029	0.968	-1.4%	0.8%	64.2%	-2.1%
May	4.101	0.943	0.000	1.000	4.046	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	4.176	0.907	0.000	1.000	4.145	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	4.225	0.934	0.000	1.000	4.170	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	4.200	0.931	0.000	1.000	4.182	0.929	0.000	1.000	-0.4%	0.3%	N/A	0.0%
Sep	4.035	0.904	0.000	1.000	3.933	0.903	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	4.025	0.941	0.001	0.999	3.972	0.942	0.000	1.000	-1.3%	0.1%	N/A	0.1%
Nov	3.241	0.918	0.015	0.984	3.157	0.918	0.123	0.866	-2.7%	0.0%	87.8%	-13.6%
Dec	2.575	0.955	0.115	0.879	2.503	0.954	0.330	0.654	-2.9%	0.1%	65.1%	-34.5%
Year	43.866	11.136	0.434	0.961	43.052	11.093	1.005	0.909	-1.9%	0.4%	56.8%	-5.7%

5.5 Analysis 1-Ratio=7.3

When ratio equals to 7.3, the storage tank volume is 584 gallons. The total collector area is 80 ft^2 and daily hot water usage is still 70 gallons/day.

5.5.1 F-Chart simulation

Figure 5-28 and Figure 5-29 show the input information for F-Chart. The changed settings are presented in a red box. Figure 5-30 gives the result summary of modified simulation.

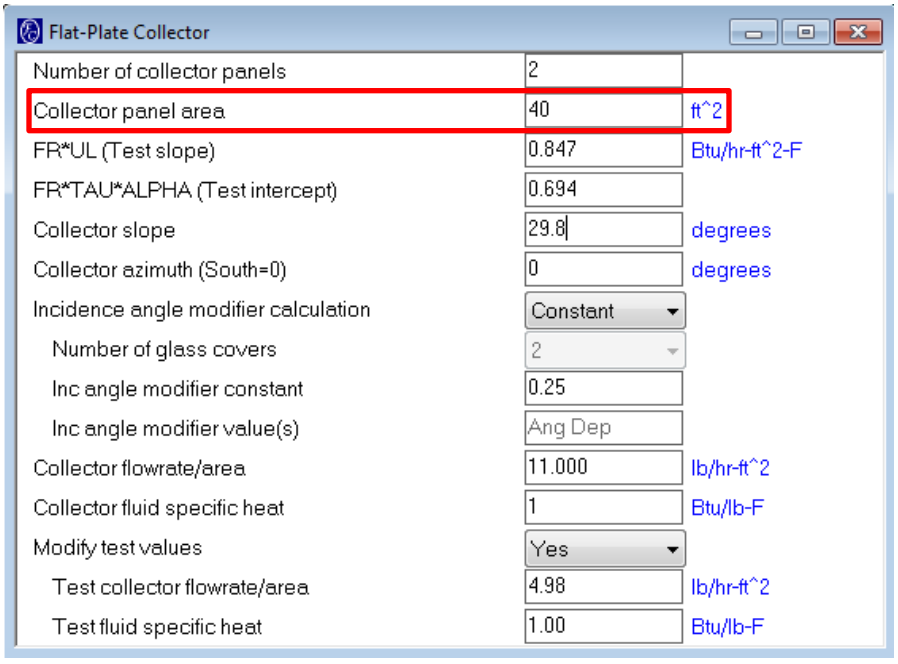


Figure 5-28 Flat-Plate Collector Input

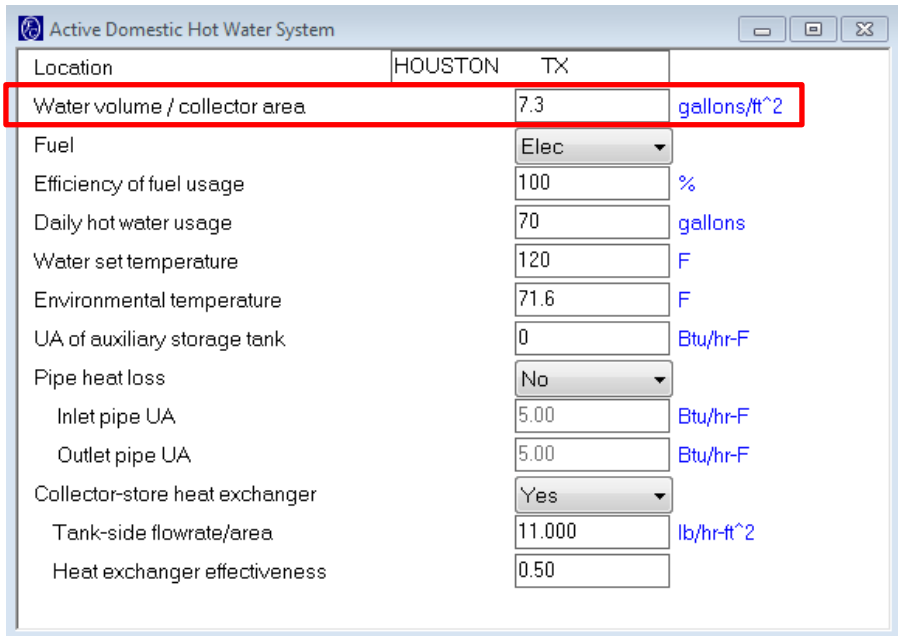
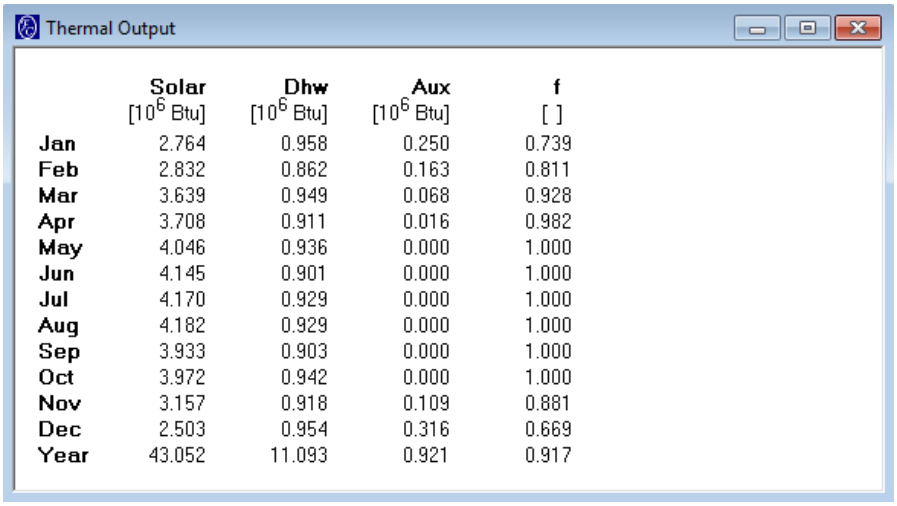


Figure 5-29 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	0.958	0.250	0.739
Feb	2.832	0.862	0.163	0.811
Mar	3.639	0.949	0.068	0.928
Apr	3.708	0.911	0.016	0.982
May	4.046	0.936	0.000	1.000
Jun	4.145	0.901	0.000	1.000
Jul	4.170	0.929	0.000	1.000
Aug	4.182	0.929	0.000	1.000
Sep	3.933	0.903	0.000	1.000
Oct	3.972	0.942	0.000	1.000
Nov	3.157	0.918	0.109	0.881
Dec	2.503	0.954	0.316	0.669
Year	43.052	11.093	0.921	0.917

Figure 5-30 F-Chart Simulation

5.5.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 5-31and Figure 5-32.

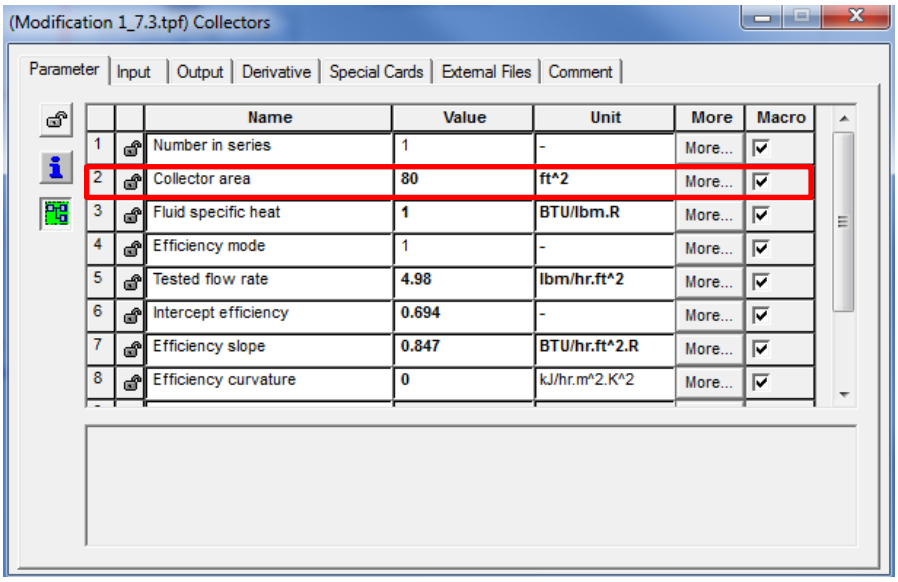


Figure 5-31 TRNSYS Component "Collectors" Settings

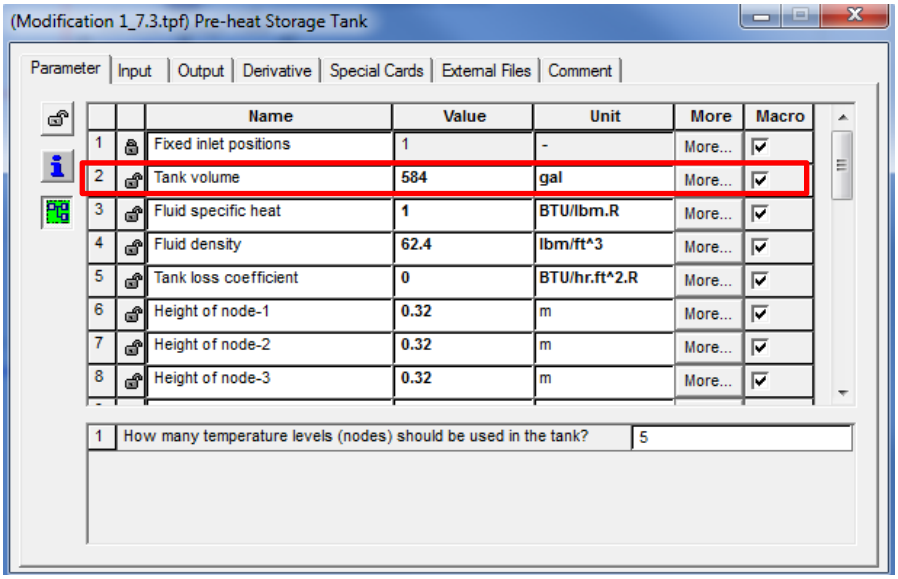


Figure 5-32 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 5-33 - Figure 5-36 present the simulation comparisons for ANALYSIS 1 (ratio=7.3) including Solar, Dhw, Aux and f factor. In Table 5-4, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 57.5% and -5.2%, respectively.

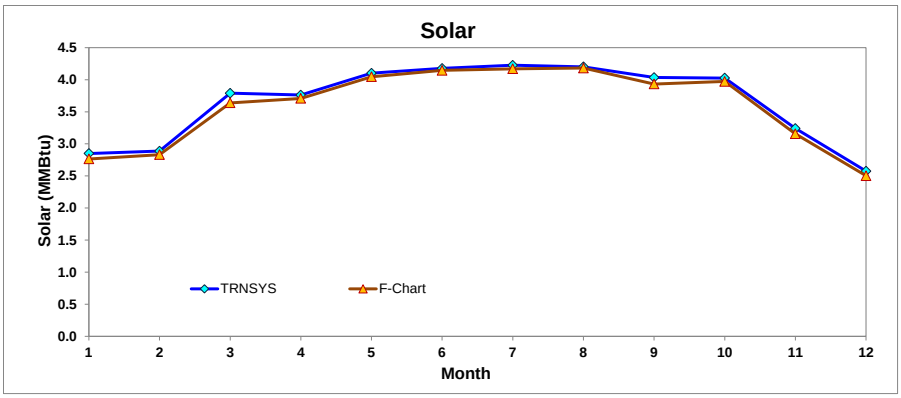


Figure 5-33 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 1 (Ratio=7.3)

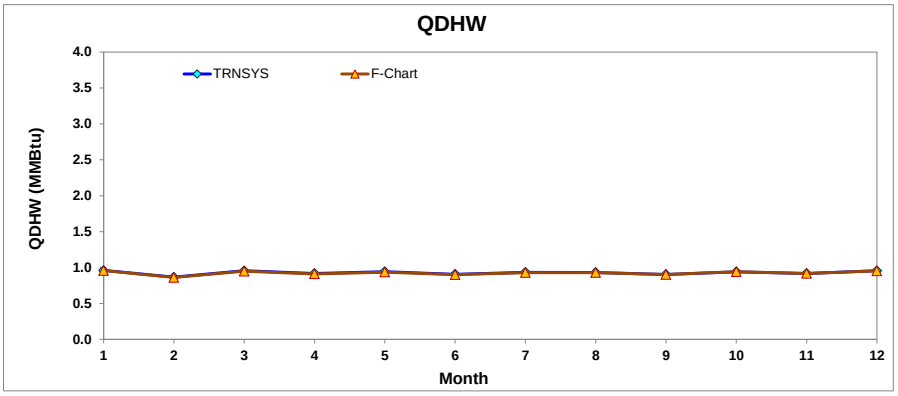


Figure 5-34Monthly Total Water Heating Demand -ANALYSIS 1 (Ratio=7.3)

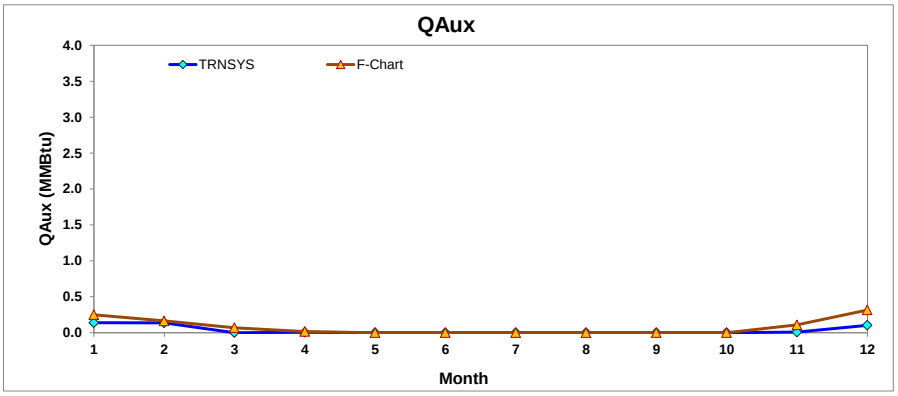


Figure 5-35Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 1 (Ratio=7.3)

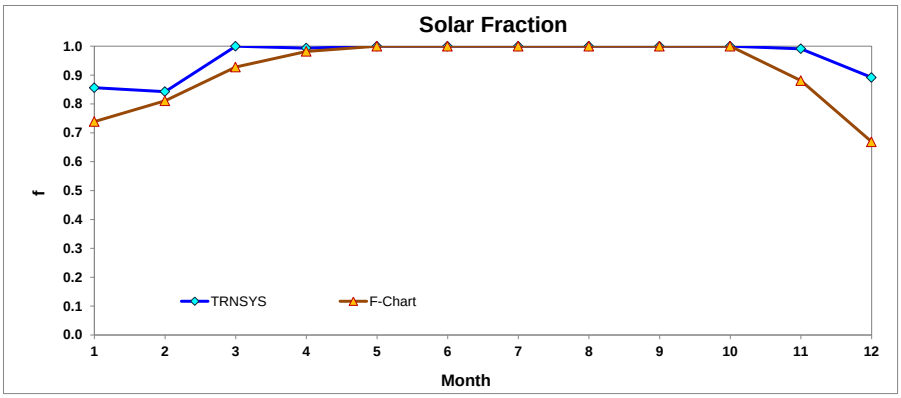


Figure 5-36 Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 1 (Ratio=7.3)

Table 5-4 Comparisons Data between TRNSYS and F-Chart ANALYSIS 1 (Ratio=7.3)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	0.961	0.138	0.856	2.764	0.958	0.250	0.739	-3.1%	-0.3%	44.7%	-15.8%
Feb	2.888	0.867	0.136	0.843	2.832	0.862	0.163	0.811	-2.0%	0.6%	16.4%	-3.9%
Mar	3.789	0.955	0.000	1.000	3.639	0.949	0.068	0.928	-4.1%	0.7%	99.9%	-7.8%
Apr	3.762	0.918	0.006	0.994	3.708	0.911	0.016	0.982	-1.4%	0.8%	63.0%	-1.2%
May	4.101	0.943	0.000	1.000	4.046	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	4.176	0.907	0.000	1.000	4.145	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	4.225	0.934	0.000	1.000	4.170	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	4.200	0.931	0.000	1.000	4.182	0.929	0.000	1.000	-0.4%	0.3%	N/A	0.0%
Sep	4.035	0.904	0.000	1.000	3.933	0.903	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	4.025	0.941	0.000	1.000	3.972	0.942	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	3.241	0.918	0.008	0.991	3.157	0.918	0.109	0.881	-2.7%	0.0%	92.6%	-12.5%
Dec	2.575	0.955	0.103	0.892	2.503	0.954	0.316	0.669	-2.9%	0.1%	67.3%	-33.3%
Year	43.866	11.136	0.392	0.965	43.052	11.093	0.921	0.917	-1.9%	0.4%	57.5%	-5.2%

5.6 Discussion

Figure 5-37 compares the f factor of SDHW system simulated by TRNSYS and F-Chart. It has shown that both results follow the same pattern and trend. As the water volume/collector area ratio increases, the f factor increases. However, it is obvious that TRNSYS simulation predicts more useful solar, compared to F-Chart simulation.

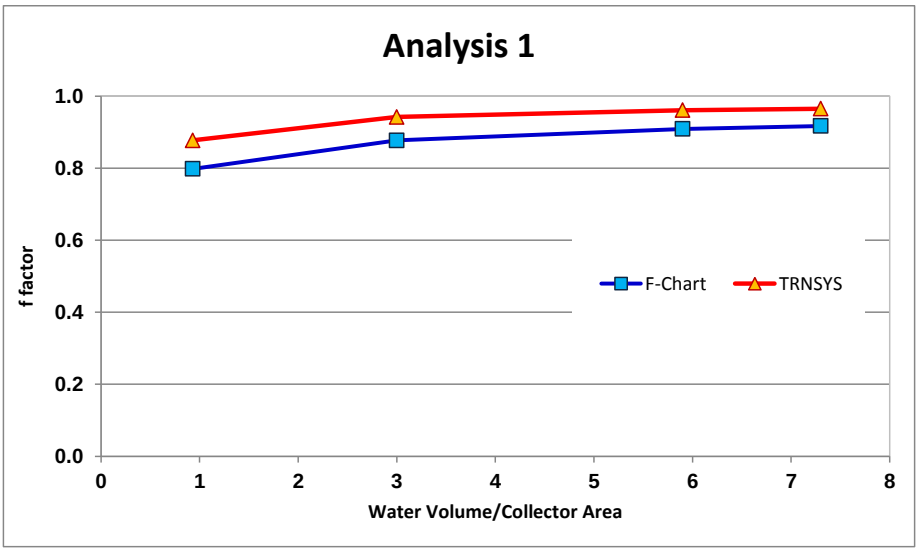


Figure 5-37 f Factor Comparisons between F-Chart and TRNSYS – ANALYSIS 1

6 SOLAR DOMESTIC HOT WATER SYSTEM SIMULATION COMPARISONS OF ANALYSIS 2 - WATER VOLUME/COLLECTOR AREA RATIO STUDY PART II

6.1 Overview

Starting from this section, different case studies are performed to further checking the simulation accuracy of TRNSYS program on SDHW System. This section will vary the total collector area from 64.02 ft^2 to 800 ft^2. With 800ft^2 total solar collector area, the water volume/collector area ratio is varied by 0.93,3, 5.9 and 7.3. This means the pre-heat storage tank volumes are varied to 744, 2400, 4720 and 5840 gallons. The other settings are kept as the same as base case.

6.2 Analysis 2-Ratio=0.93

When ratio equals to 0.93, the storage tank volume is 744 gallons. The total collector area is 800 ft^2 and daily hot water usage is still 70 gallons/day.

6.2.1 F-Chart simulation

Figure 6-1and Figure 6-2 show the input information for F-Chart. The changed settings are presented in a red box. Figure 6-3gives the result summary of modified simulation.

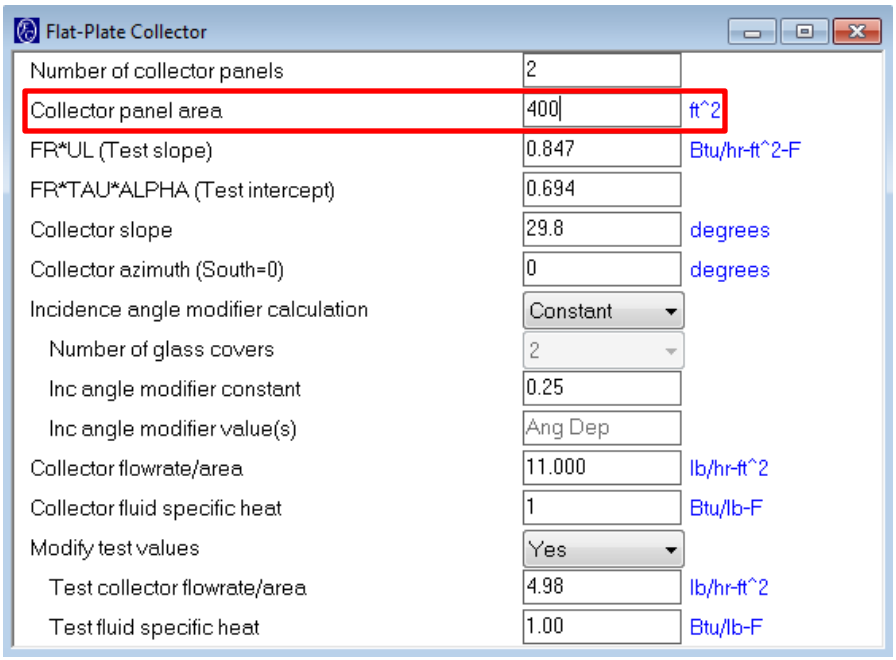


Figure 6-1 Flat-Plate Collector Input

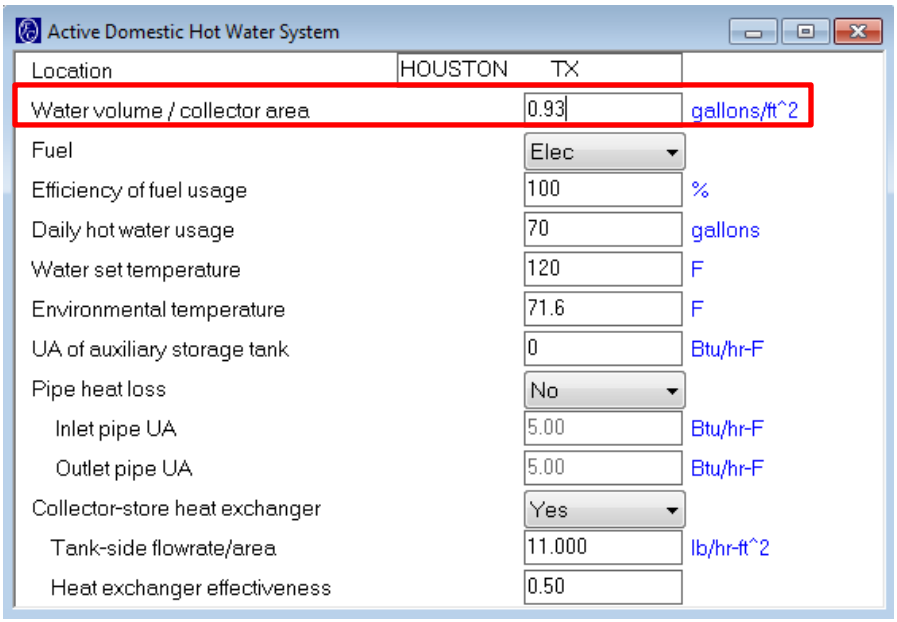
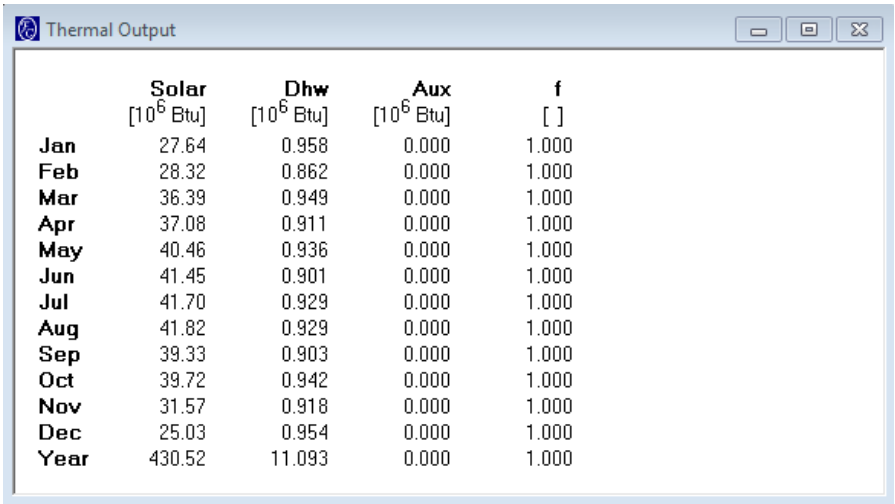


Figure 6-2 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	0.958	0.000	1.000
Feb	28.32	0.862	0.000	1.000
Mar	36.39	0.949	0.000	1.000
Apr	37.08	0.911	0.000	1.000
May	40.46	0.936	0.000	1.000
Jun	41.45	0.901	0.000	1.000
Jul	41.70	0.929	0.000	1.000
Aug	41.82	0.929	0.000	1.000
Sep	39.33	0.903	0.000	1.000
Oct	39.72	0.942	0.000	1.000
Nov	31.57	0.918	0.000	1.000
Dec	25.03	0.954	0.000	1.000
Year	430.52	11.093	0.000	1.000

Figure 6-3 F-Chart Simulation

6.2.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 6-4 and Figure 6-5.

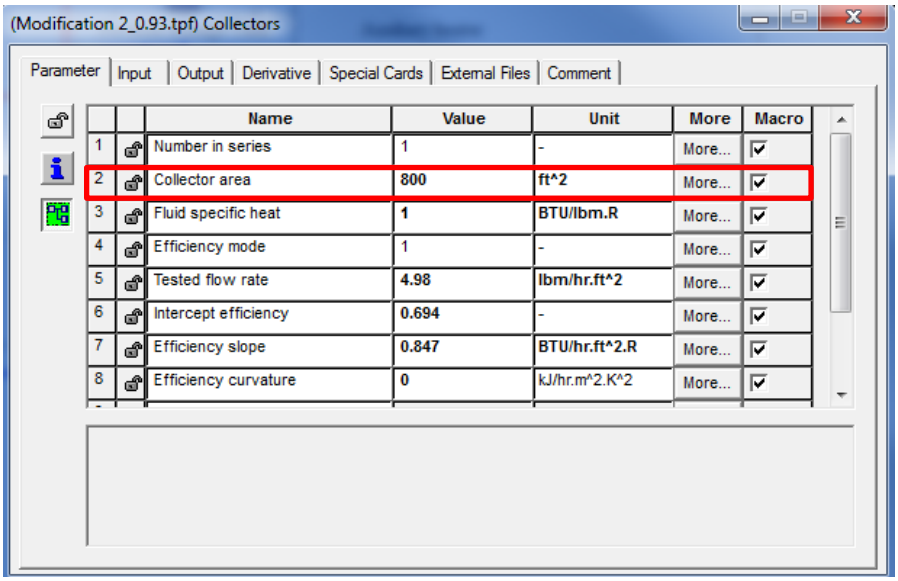


Figure 6-4 TRNSYS Component “Collectors” Settings

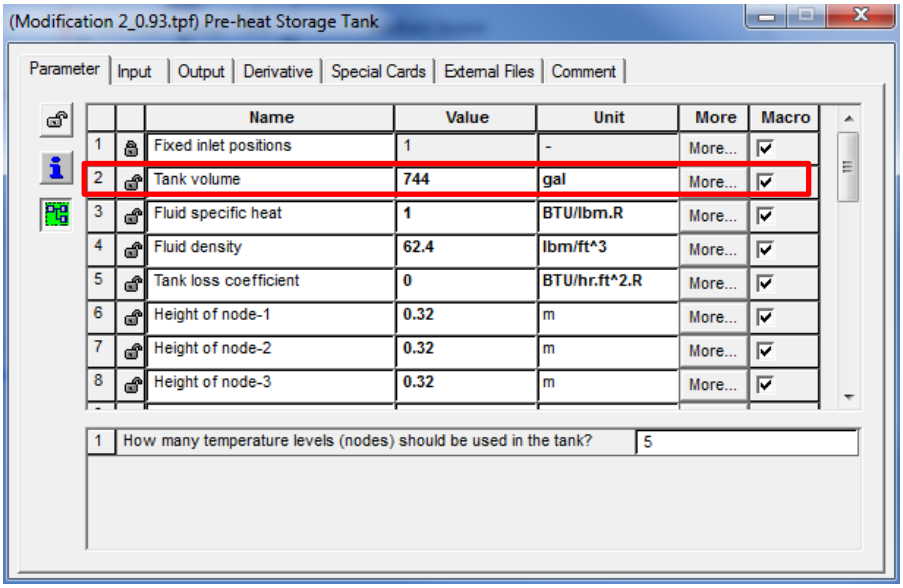


Figure 6-5 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 6-6 - Figure 6-9 present the simulation comparisons for ANALYSIS 2 (ratio=0.93) including Solar, Dhw, Aux and f factor. In Table 6-1, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

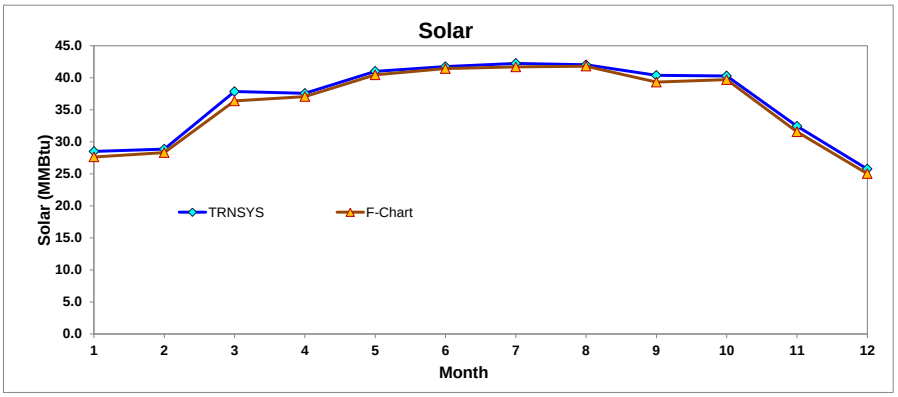


Figure 6-6 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 2 (Ratio=0.93)

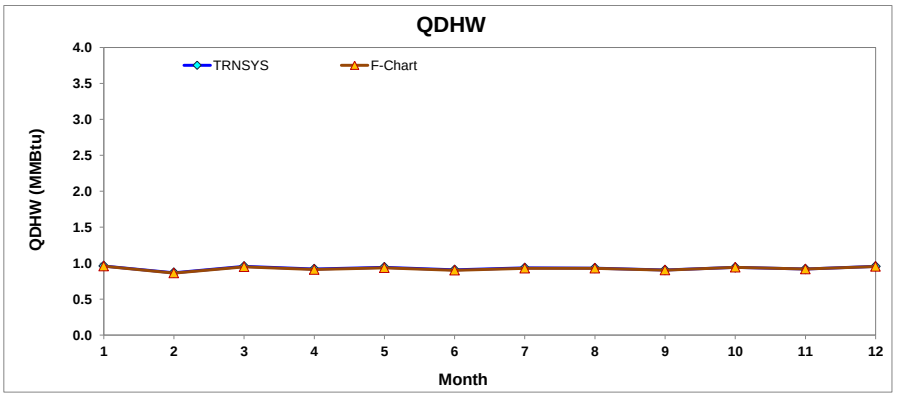


Figure 6-7Monthly Total Water Heating Demand -ANALYSIS 2 (Ratio=0.93)

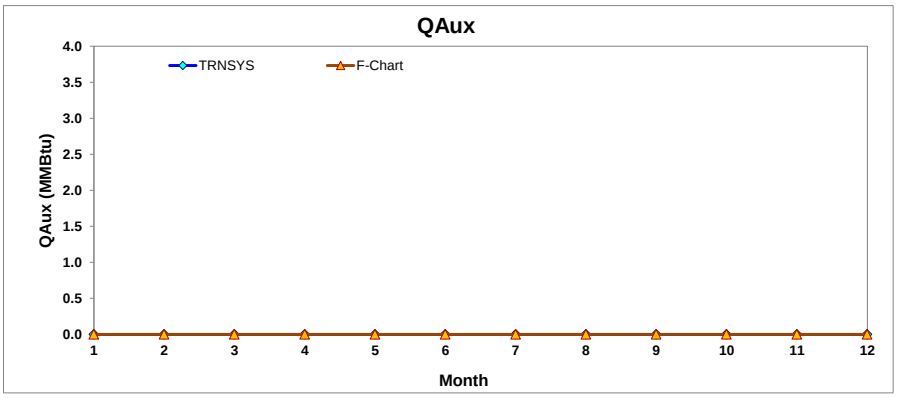


Figure 6-8Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 2 (Ratio=0.93)

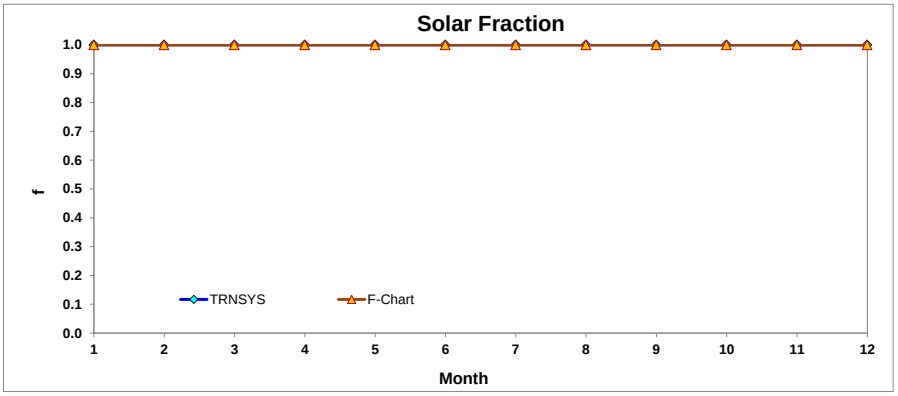


Figure 6-9Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 2 (Ratio=0.93)

Table 6-1 Comparisons Data between TRNSYS and F-Chart ANALYSIS 2 (Ratio=0.93)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	0.961	0.000	1.000	27.640	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	28.856	0.867	0.000	1.000	28.320	0.862	0.000	1.000	-1.9%	0.6%	N/A	0.0%
Mar	37.856	0.955	0.000	1.000	36.390	0.949	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	37.573	0.918	0.000	1.000	37.080	0.911	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	41.013	0.943	0.000	1.000	40.460	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.751	0.907	0.000	1.000	41.450	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.258	0.934	0.000	1.000	41.700	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.033	0.931	0.000	1.000	41.820	0.929	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	40.389	0.904	0.000	1.000	39.330	0.903	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	0.941	0.000	1.000	39.720	0.942	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	32.452	0.918	0.000	1.000	31.570	0.918	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	25.754	0.955	0.000	1.000	25.030	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.730	11.136	0.000	1.000	430.520	11.093	0.000	1.000	-1.9%	0.4%	N/A	0.0%

6.3 Analysis 2-Ratio=3

When ratio equals to 3, the storage tank volume is 2400 gallons. The total collector area is 800 ft^2 and daily hot water usage is still 70 gallons/day.

6.3.1 F-Chart simulation

Figure 6-10 and Figure 6-11 show the input information for F-Chart. The changed settings are presented in a red box. Figure 6-12 gives the result summary of modified simulation.

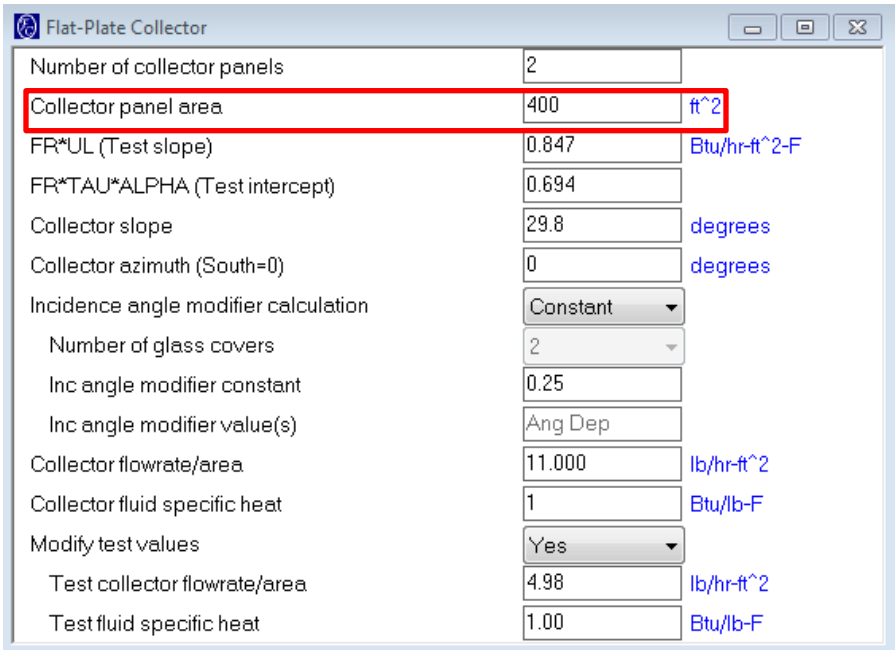


Figure 6-10 Flat-Plate Collector Input

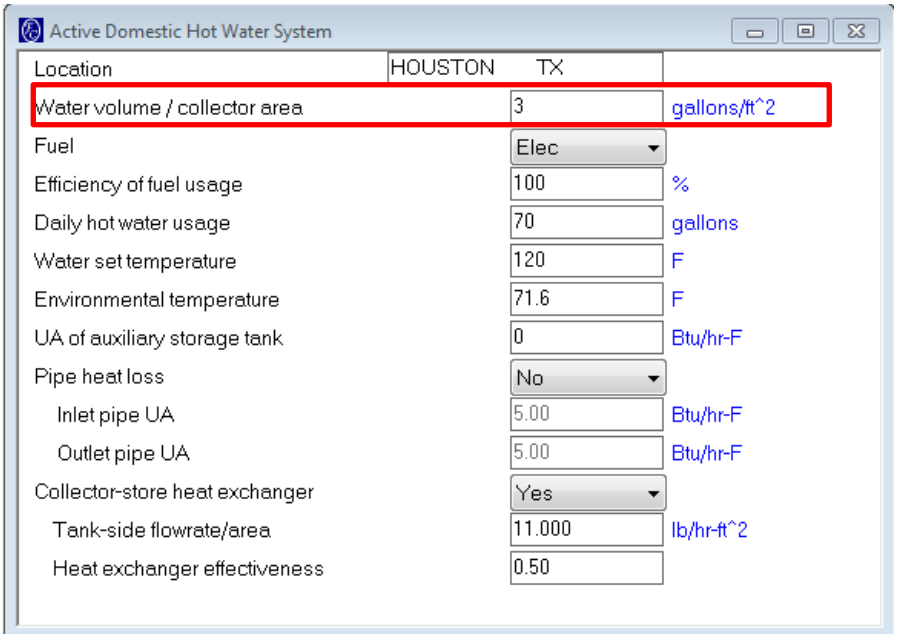
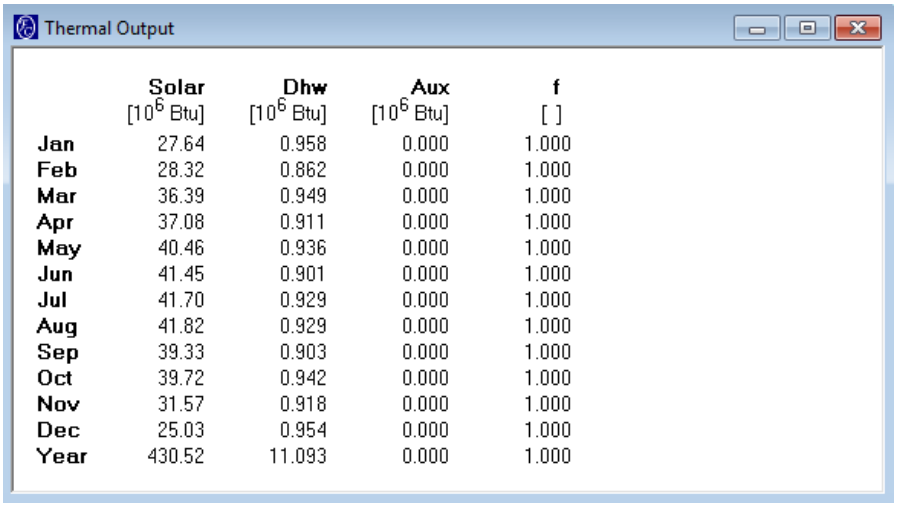


Figure 6-11 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	0.958	0.000	1.000
Feb	28.32	0.862	0.000	1.000
Mar	36.39	0.949	0.000	1.000
Apr	37.08	0.911	0.000	1.000
May	40.46	0.936	0.000	1.000
Jun	41.45	0.901	0.000	1.000
Jul	41.70	0.929	0.000	1.000
Aug	41.82	0.929	0.000	1.000
Sep	39.33	0.903	0.000	1.000
Oct	39.72	0.942	0.000	1.000
Nov	31.57	0.918	0.000	1.000
Dec	25.03	0.954	0.000	1.000
Year	430.52	11.093	0.000	1.000

Figure 6-12 F-Chart Simulation

6.3.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 6-13 and Figure 6-14.

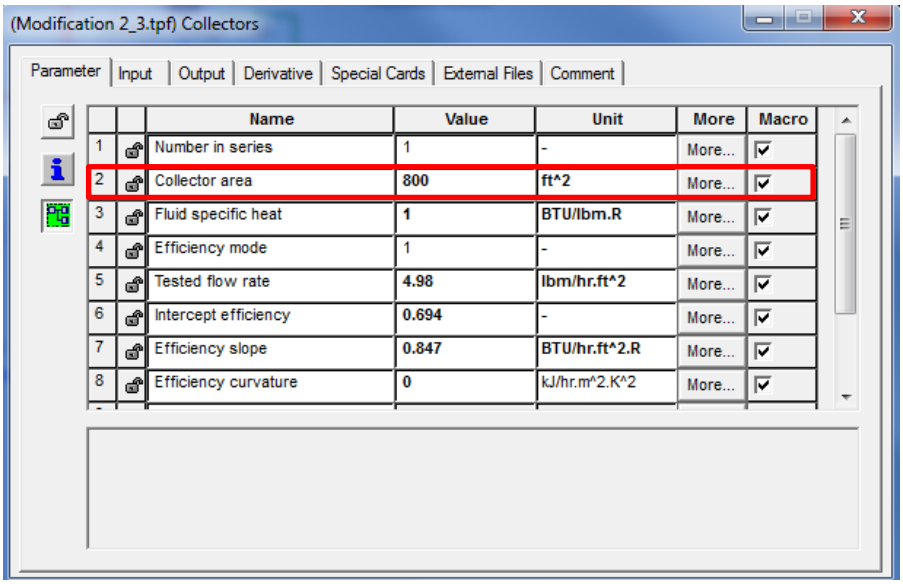


Figure 6-13 TRNSYS Component "Collectors" Settings

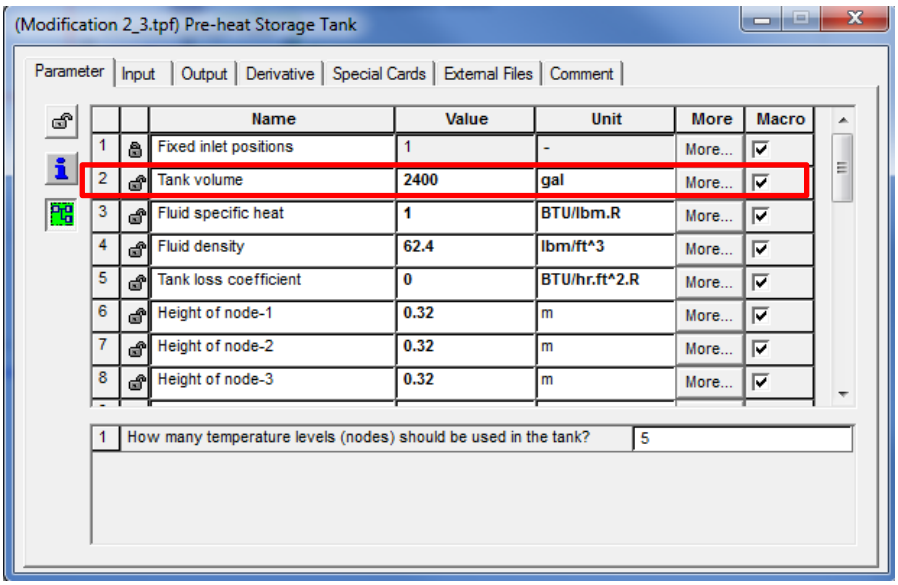


Figure 6-14 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 6-15 - Figure 6-18 present the simulation comparisons for ANALYSIS 1 (ratio=3) including Solar, Dhw, Aux and f factor. In Table 6-2, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

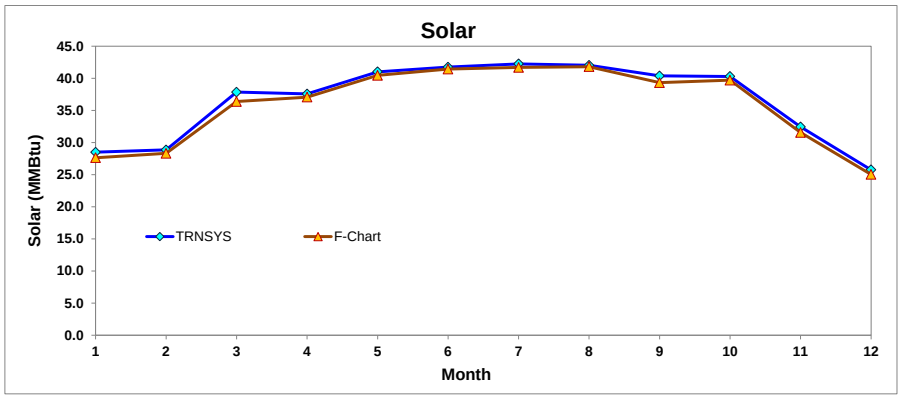


Figure 6-15 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 2 (Ratio=3)

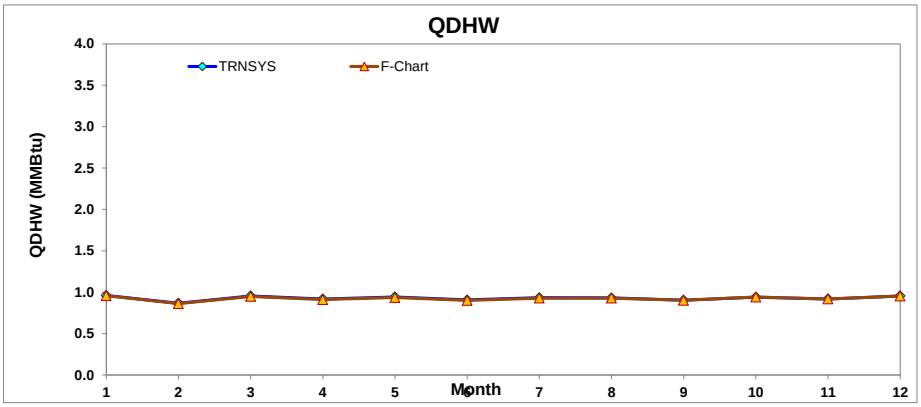


Figure 6-16Monthly Total Water Heating Demand -ANALYSIS 2 (Ratio=3)

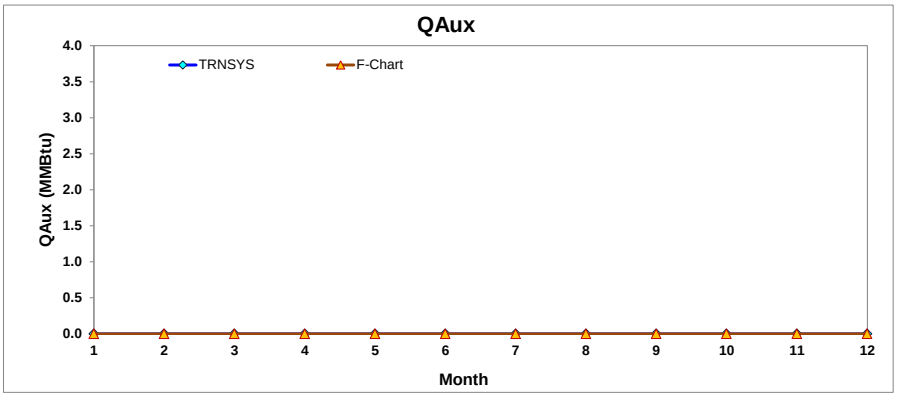


Figure 6-17Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 2 (Ratio=3)

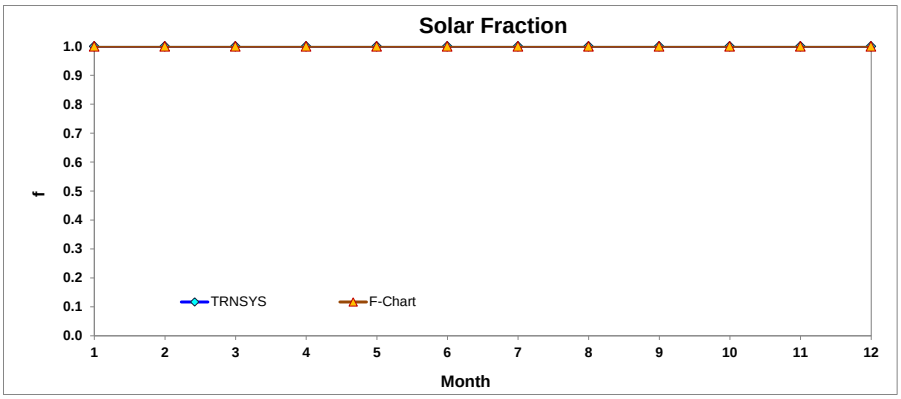


Figure 6-18Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 2 (Ratio=3)

Table 6-2 Comparisons Data between TRNSYS and F-Chart ANALYSIS 2 (Ratio=3)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	0.961	0.000	1.000	27.640	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	28.856	0.867	0.000	1.000	28.320	0.862	0.000	1.000	-1.9%	0.6%	N/A	0.0%
Mar	37.856	0.955	0.000	1.000	36.390	0.949	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	37.573	0.918	0.000	1.000	37.080	0.911	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	41.013	0.943	0.000	1.000	40.460	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.751	0.907	0.000	1.000	41.450	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.258	0.934	0.000	1.000	41.700	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.033	0.931	0.000	1.000	41.820	0.929	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	40.389	0.904	0.000	1.000	39.330	0.903	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	0.941	0.000	1.000	39.720	0.942	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	32.452	0.918	0.000	1.000	31.570	0.918	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	25.754	0.955	0.000	1.000	25.030	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.730	11.136	0.000	1.000	430.520	11.093	0.000	1.000	-1.9%	0.4%	N/A	0.0%

6.4 Analysis 2-Ratio=5.9

When ratio equals to 5.9, the storage tank volume is 4720 gallons. The total collector area is 800 ft^2 and daily hot water usage is still 70 gallons/day.

6.4.1 F-Chart simulation

Figure 6-19 and Figure 6-20 show the input information for F-Chart. The changed settings are presented in a red box. Figure 6-3 gives the result summary of modified simulation.

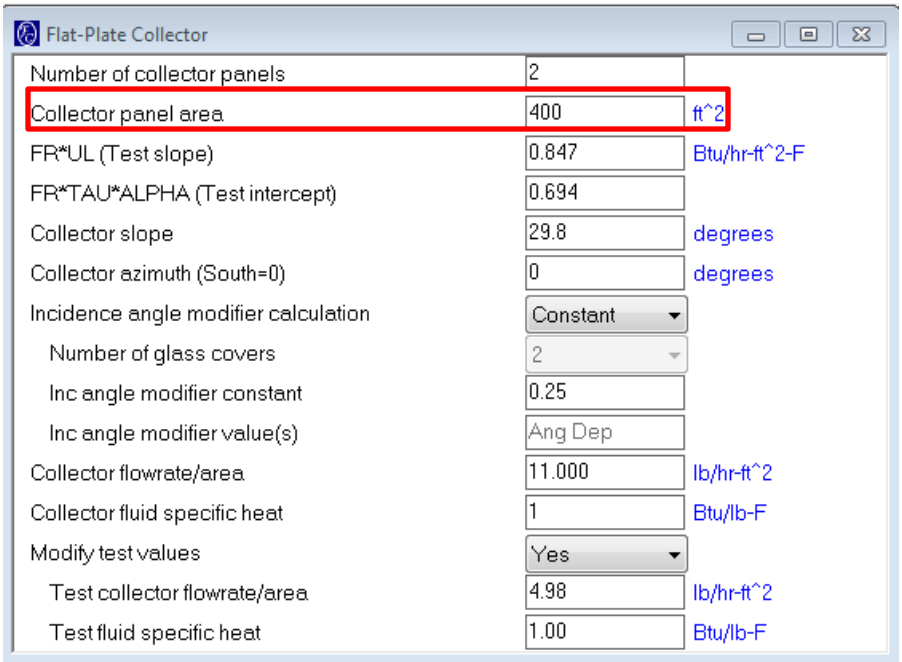


Figure 6-19 Flat-Plate Collector Input

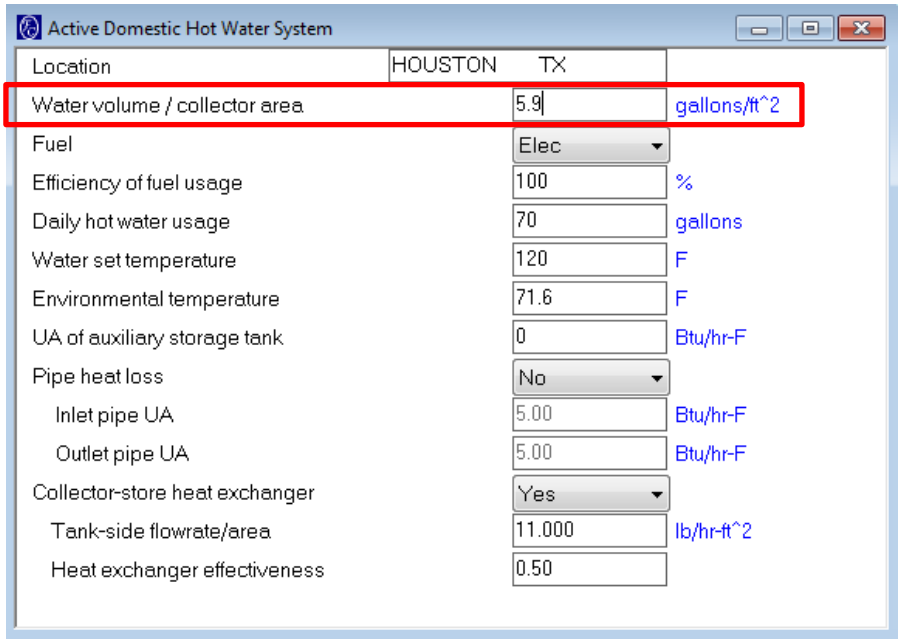
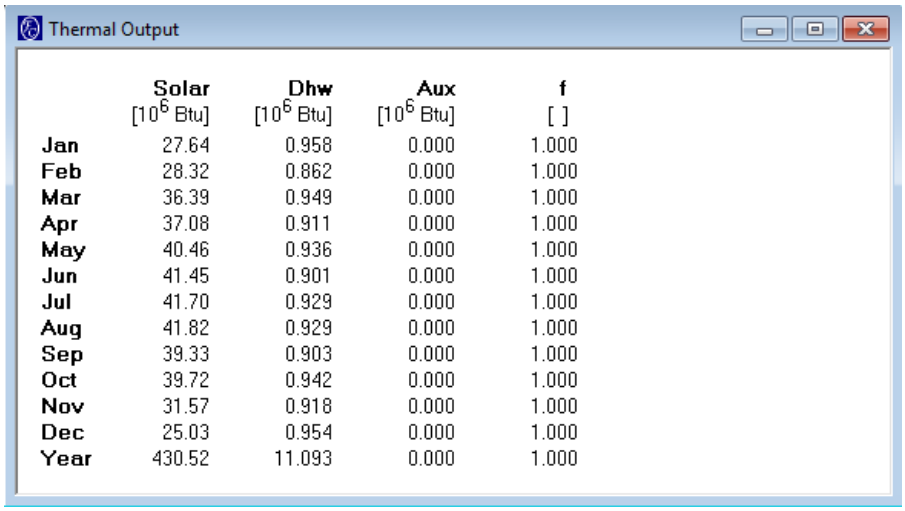


Figure 6-20 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	0.958	0.000	1.000
Feb	28.32	0.862	0.000	1.000
Mar	36.39	0.949	0.000	1.000
Apr	37.08	0.911	0.000	1.000
May	40.46	0.936	0.000	1.000
Jun	41.45	0.901	0.000	1.000
Jul	41.70	0.929	0.000	1.000
Aug	41.82	0.929	0.000	1.000
Sep	39.33	0.903	0.000	1.000
Oct	39.72	0.942	0.000	1.000
Nov	31.57	0.918	0.000	1.000
Dec	25.03	0.954	0.000	1.000
Year	430.52	11.093	0.000	1.000

Figure 6-21 F-Chart Simulation

6.4.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 6-22 and Figure 6-23.

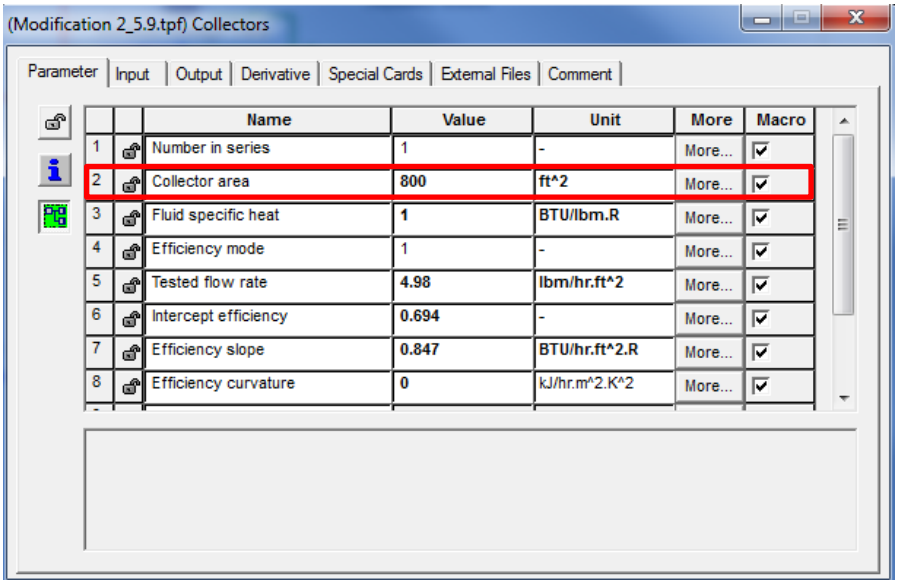


Figure 6-22 TRNSYS Component “Collectors” Settings

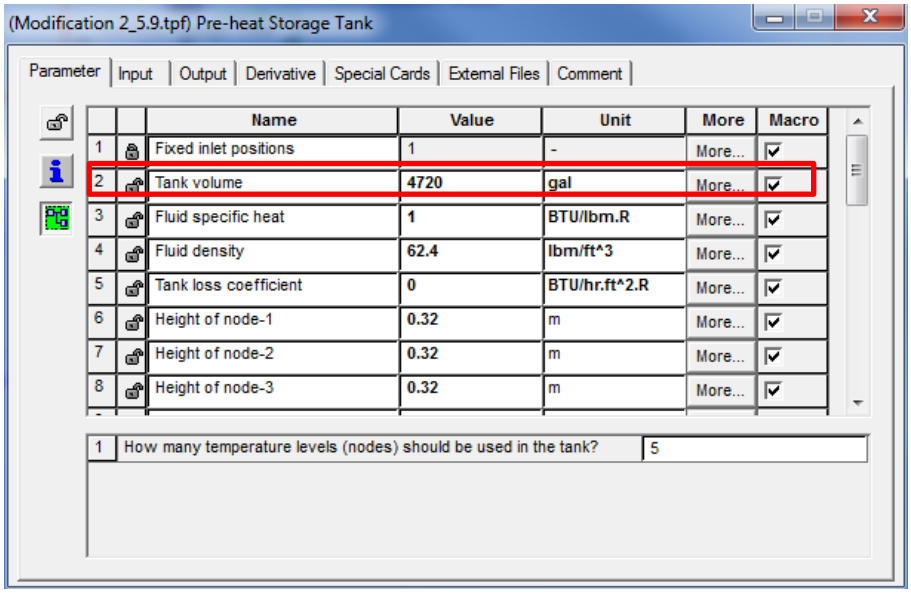


Figure 6-23 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 6-24 - Figure 6-27 present the simulation comparisons for ANALYSIS 1 (ratio=5.9) including Solar, Dhw, Aux and f factor. In Table 6-3 , Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0%, respectively.

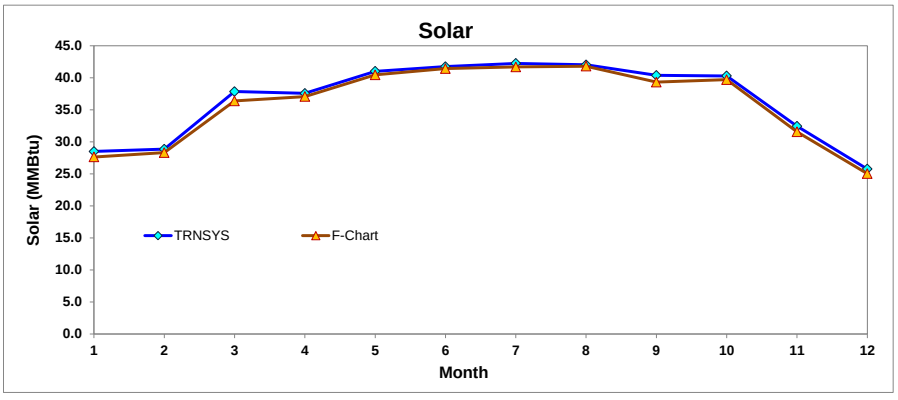


Figure 6-24 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 2 (Ratio=5.9)

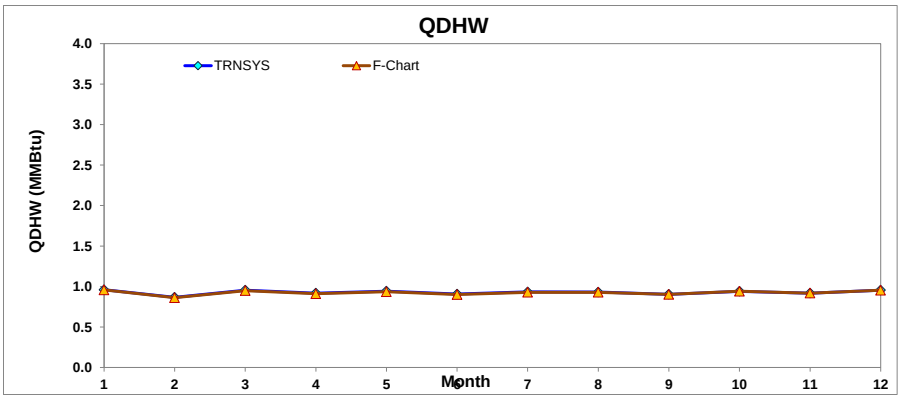


Figure 6-25Monthly Total Water Heating Demand -ANALYSIS 2 (Ratio=5.9)

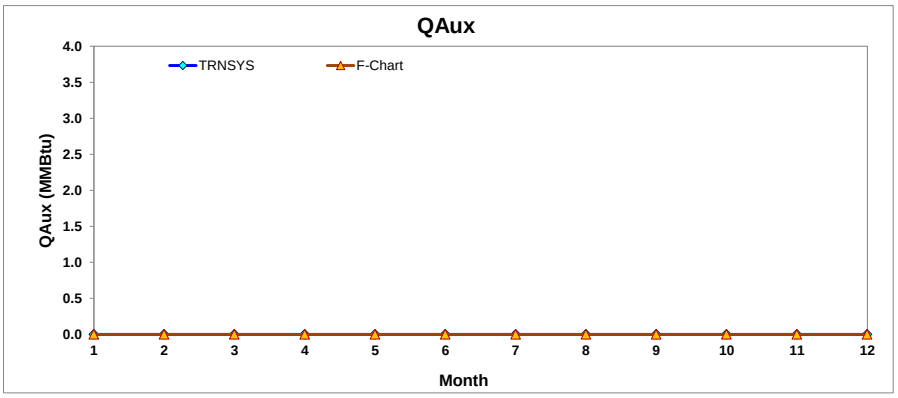


Figure 6-26Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 2 (Ratio=5.9)

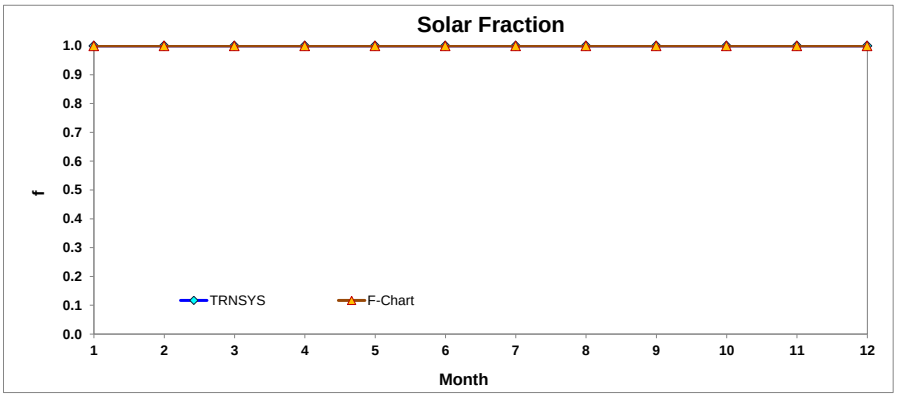


Figure 6-27Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 2 (Ratio=5.9)

Table 6-3 Comparisons Data between TRNSYS and F-Chart ANALYSIS 2 (Ratio=5.9)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	0.961	0.000	1.000	27.640	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	28.856	0.867	0.000	1.000	28.320	0.862	0.000	1.000	-1.9%	0.6%	N/A	0.0%
Mar	37.856	0.955	0.000	1.000	36.390	0.949	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	37.573	0.918	0.000	1.000	37.080	0.911	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	41.013	0.943	0.000	1.000	40.460	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.751	0.907	0.000	1.000	41.450	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.258	0.934	0.000	1.000	41.700	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.033	0.931	0.000	1.000	41.820	0.929	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	40.389	0.904	0.000	1.000	39.330	0.903	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	0.941	0.000	1.000	39.720	0.942	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	32.452	0.918	0.000	1.000	31.570	0.918	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	25.754	0.955	0.000	1.000	25.030	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.730	11.136	0.000	1.000	430.520	11.093	0.000	1.000	-1.9%	0.4%	N/A	0.0%

6.5 Analysis 2-Ratio=7.3

When ratio equals to 7.3, the storage tank volume is 5840 gallons. The total collector area is 800 ft^2 and daily hot water usage is still 70 gallons/day.

6.5.1 F-Chart simulation

Figure 6-28 and Figure 6-29 show the input information for F-Chart. The changed settings are presented in a red box. Figure 6-30 gives the result summary of modified simulation.

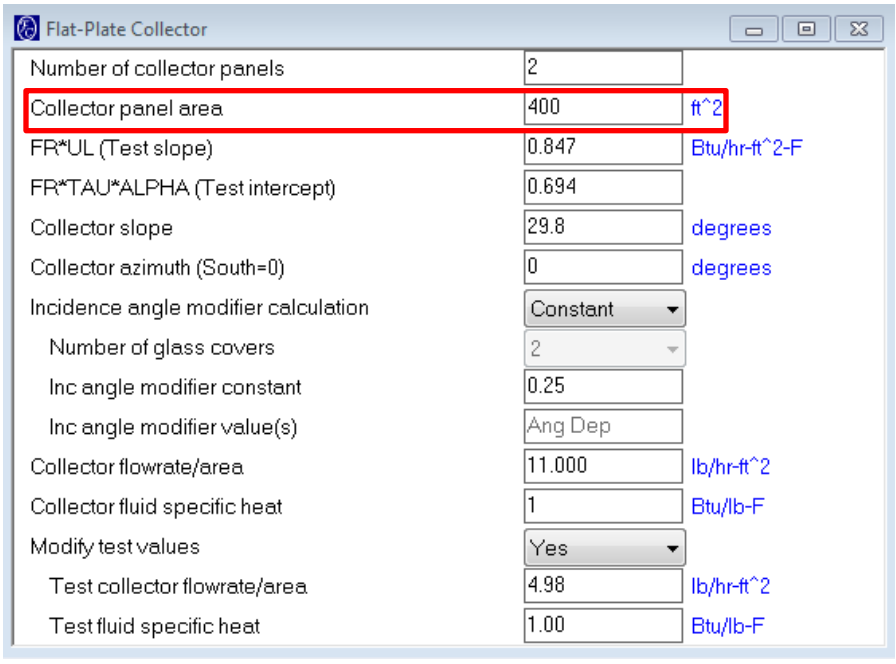


Figure 6-28 Flat-Plate Collector Input

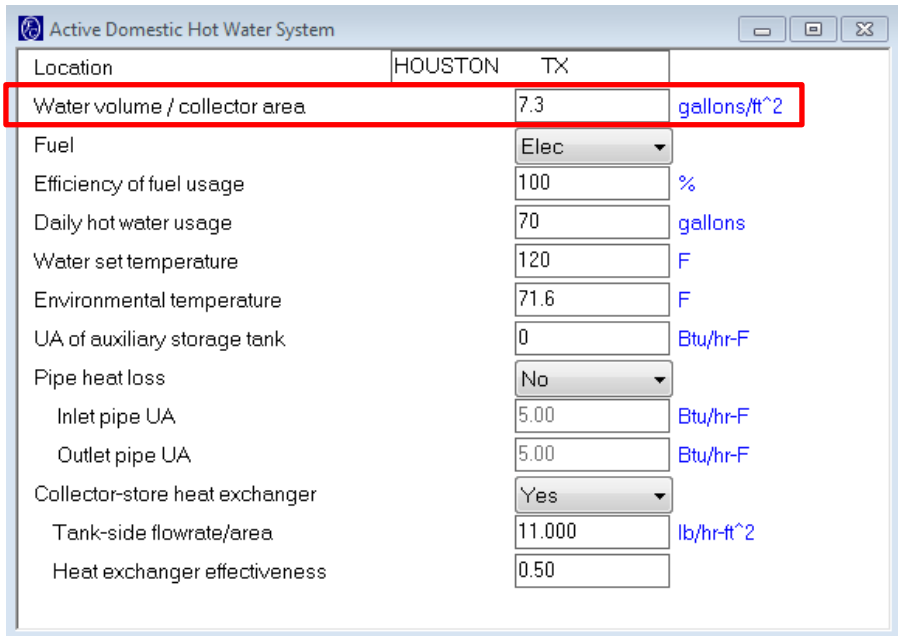
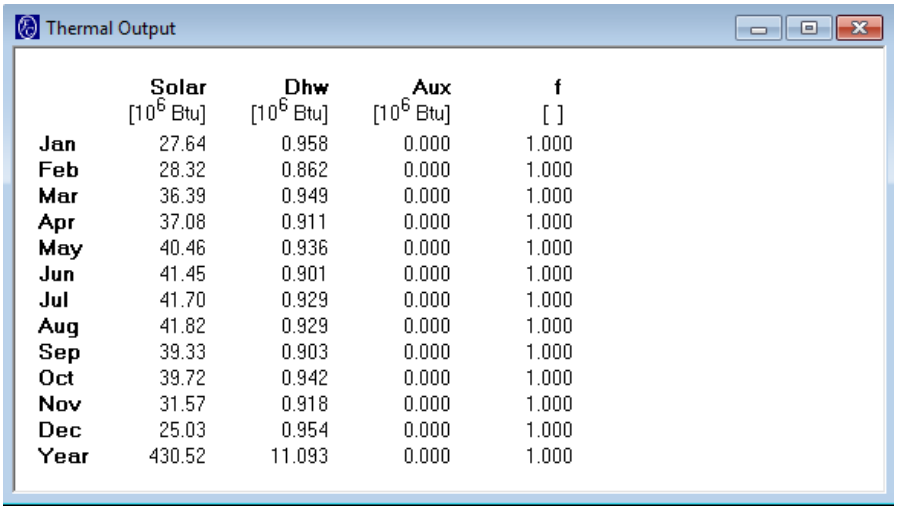


Figure 6-29 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	0.958	0.000	1.000
Feb	28.32	0.862	0.000	1.000
Mar	36.39	0.949	0.000	1.000
Apr	37.08	0.911	0.000	1.000
May	40.46	0.936	0.000	1.000
Jun	41.45	0.901	0.000	1.000
Jul	41.70	0.929	0.000	1.000
Aug	41.82	0.929	0.000	1.000
Sep	39.33	0.903	0.000	1.000
Oct	39.72	0.942	0.000	1.000
Nov	31.57	0.918	0.000	1.000
Dec	25.03	0.954	0.000	1.000
Year	430.52	11.093	0.000	1.000

Figure 6-30 F-Chart Simulation

6.5.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 6-31 and Figure 6-32.

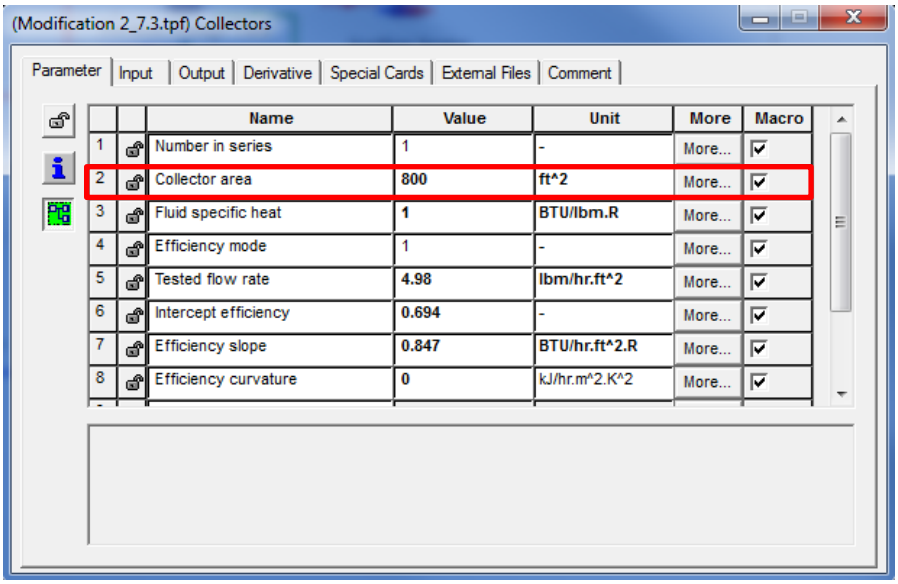


Figure 6-31 TRNSYS Component "Collectors" Settings

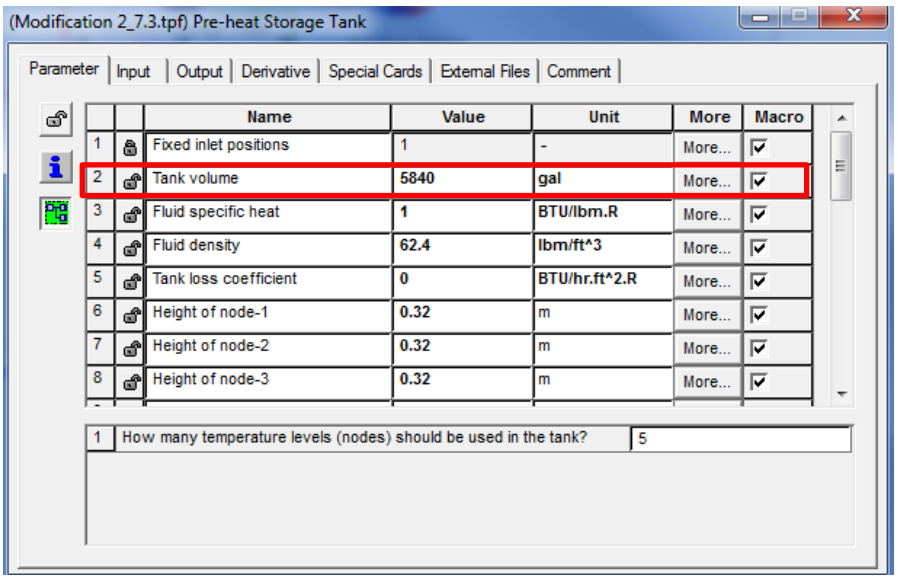


Figure 6-32 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 6-33 - Figure 6-36 present the simulation comparisons for ANALYSIS 2 (ratio=7.3) including Solar, Dhw, Aux and f factor. In Table 6-4, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0%, respectively.

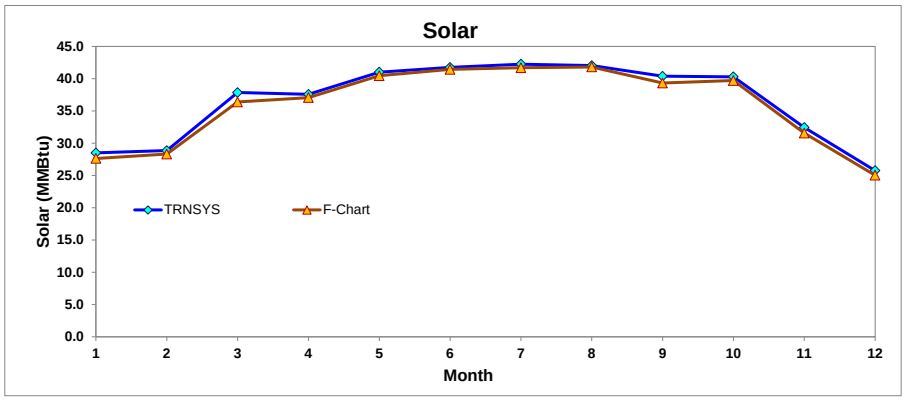


Figure 6-33 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 2 (Ratio=7.3)

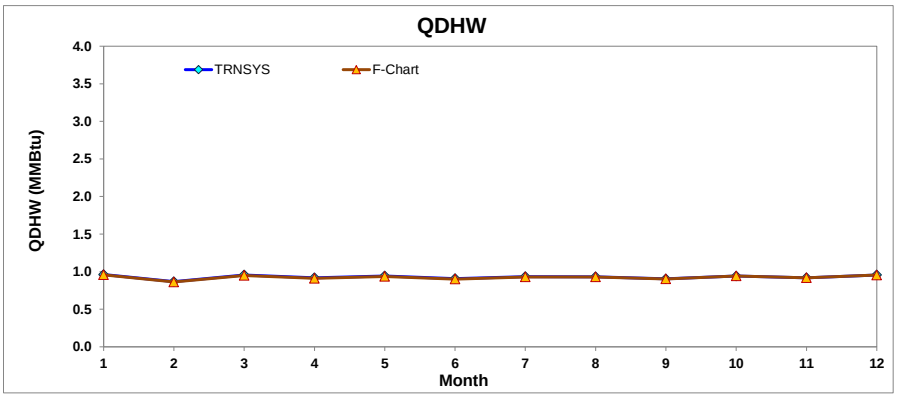


Figure 6-34Monthly Total Water Heating Demand -ANALYSIS 2 (Ratio=7.3)

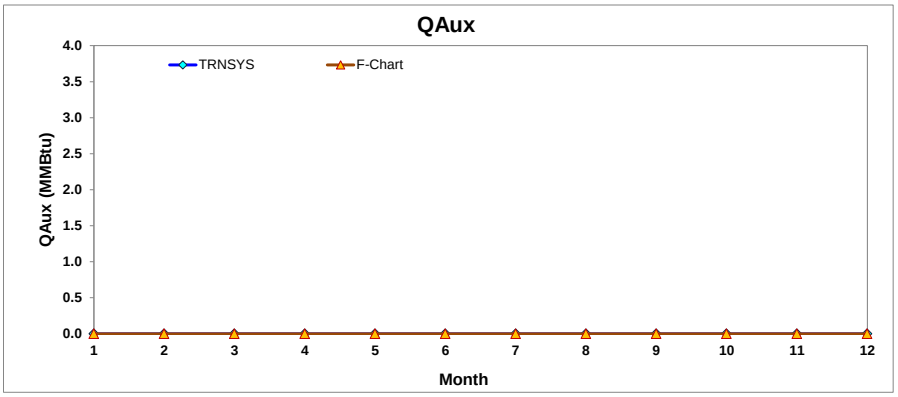


Figure 6-35Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 2 (Ratio=7.3)

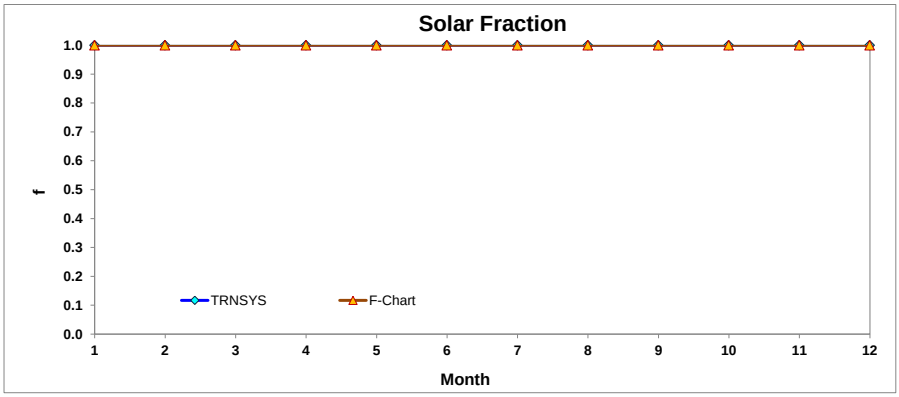


Figure 6-36 Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 2 (Ratio=7.3)

Table 6-4 Comparisons Data between TRNSYS and F-Chart ANALYSIS 2 (Ratio=7.3)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	0.961	0.000	1.000	27.640	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	28.856	0.867	0.000	1.000	28.320	0.862	0.000	1.000	-1.9%	0.6%	N/A	0.0%
Mar	37.856	0.955	0.000	1.000	36.390	0.949	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	37.573	0.918	0.000	1.000	37.080	0.911	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	41.013	0.943	0.000	1.000	40.460	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.751	0.907	0.000	1.000	41.450	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.258	0.934	0.000	1.000	41.700	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.033	0.931	0.000	1.000	41.820	0.929	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	40.389	0.904	0.000	1.000	39.330	0.903	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	0.941	0.000	1.000	39.720	0.942	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	32.452	0.918	0.000	1.000	31.570	0.918	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	25.754	0.955	0.000	1.000	25.030	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.730	11.136	0.000	1.000	430.520	11.093	0.000	1.000	-1.9%	0.4%	N/A	0.0%

6.6 Discussion

Figure 6-37 compares the f factor of SDHW system simulated by TRNSYS and F-Chart. It has shown that both results follow exact same pattern and trend. As the water volume/collector area ratio increases, the f factor is 1. This is because the solar collector area is so large that it can well support the hot water demand.

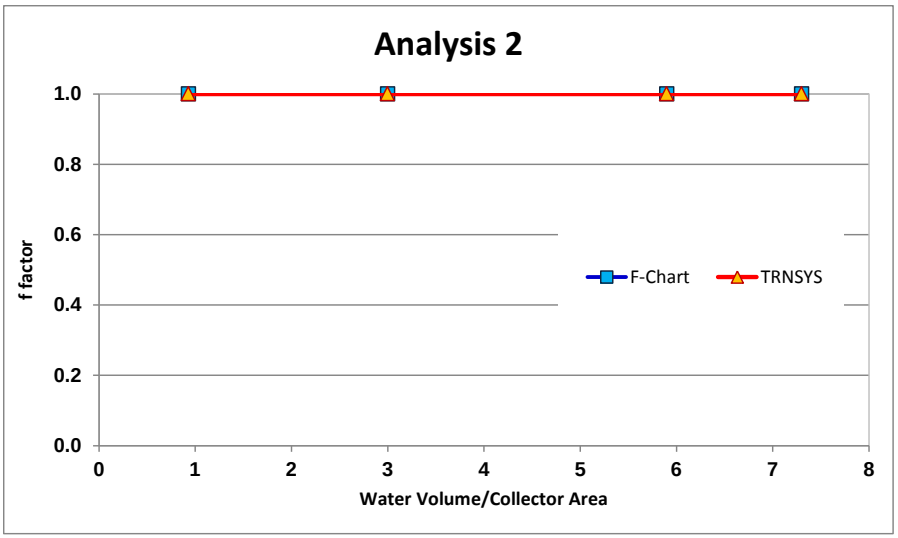


Figure 6-37 f Factor Comparisons between F-Chart and TRNSYS – ANALYSIS 2

7 SOLAR DOMESTIC HOT WATER SYSTEM SIMULATION COMPARISONS OF ANALYSIS 3 - WATER VOLUME/COLLECTOR AREA RATIO STUDY PART III

7.1 Overview

Starting from this section, different case studies are performed to further checking the simulation accuracy of TRNSYS program on SDHW System. This section will vary the total collector area from 64.02 ft^2 to 8000 ft^2. With 8000ft^2 total solar collector area, the water volume/collector area ratio is varied by 0.93,3, 5.9 and 7.3. This means the pre-heat storage tank volumes are varied to 7440, 24000, 47200 and 58400 gallons. The other settings are kept as the same as base case.

7.2 Analysis 3-Ratio=0.93

When ratio equals to 0.93, the storage tank volume is 7440 gallons. The total collector area is 8000 ft^2 and daily hot water usage is still 70 gallons/day.

7.2.1 F-Chart simulation

Figure 7-1 and Figure 7-2 show the input information for F-Chart. The changed settings are presented in a red box. Figure 7-3 gives the result summary of modified simulation.

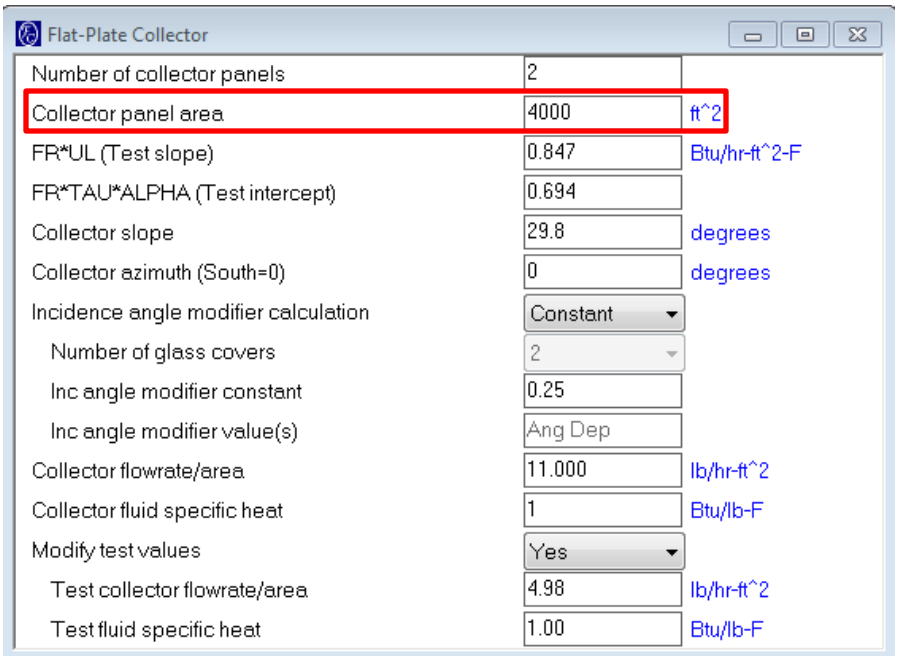


Figure 7-1 Flat-Plate Collector Input

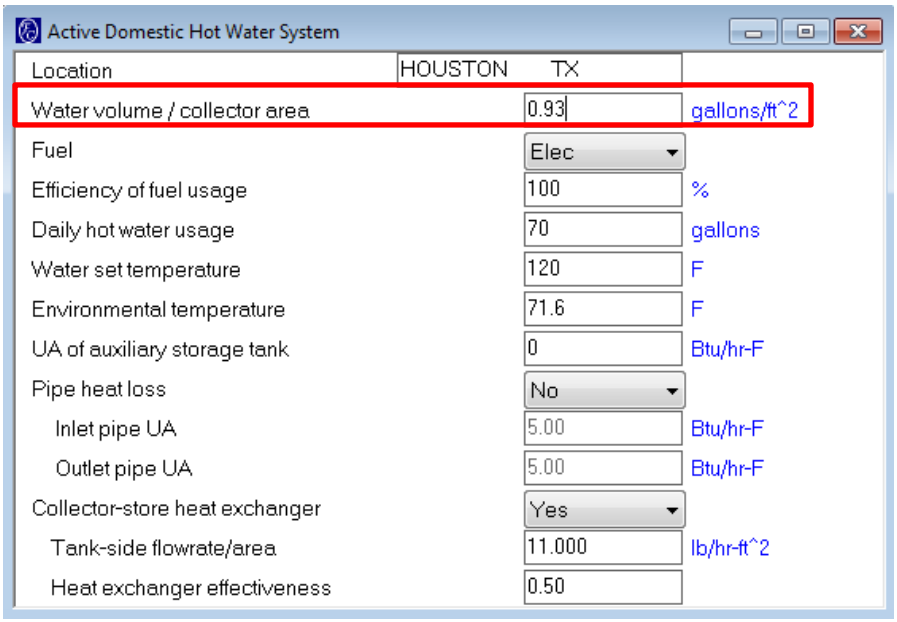
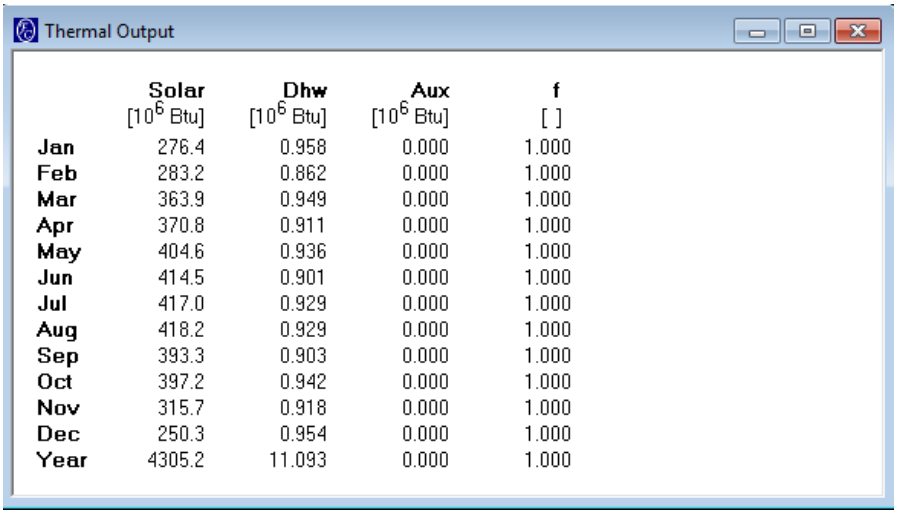


Figure 7-2 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	0.958	0.000	1.000
Feb	283.2	0.862	0.000	1.000
Mar	363.9	0.949	0.000	1.000
Apr	370.8	0.911	0.000	1.000
May	404.6	0.936	0.000	1.000
Jun	414.5	0.901	0.000	1.000
Jul	417.0	0.929	0.000	1.000
Aug	418.2	0.929	0.000	1.000
Sep	393.3	0.903	0.000	1.000
Oct	397.2	0.942	0.000	1.000
Nov	315.7	0.918	0.000	1.000
Dec	250.3	0.954	0.000	1.000
Year	4305.2	11.093	0.000	1.000

Figure 7-3 F-Chart Simulation

7.2.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 7-4 and Figure 7-5.

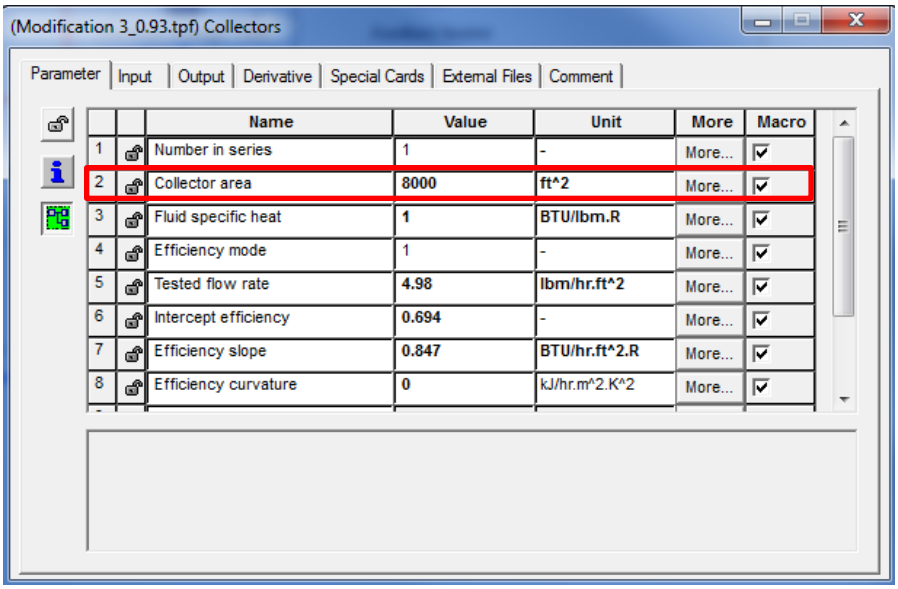


Figure 7-4 TRNSYS Component “Collectors” Settings

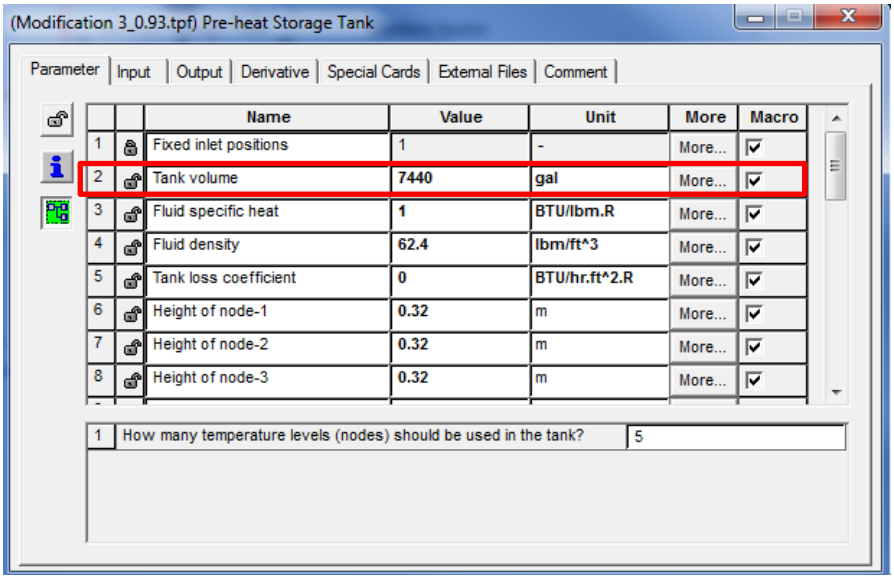


Figure 7-5 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 7-6 - Figure 7-9 present the simulation comparisons for ANALYSIS 2 (ratio=0.93) including Solar, Dhw, Aux and f factor. In Table 7-1, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

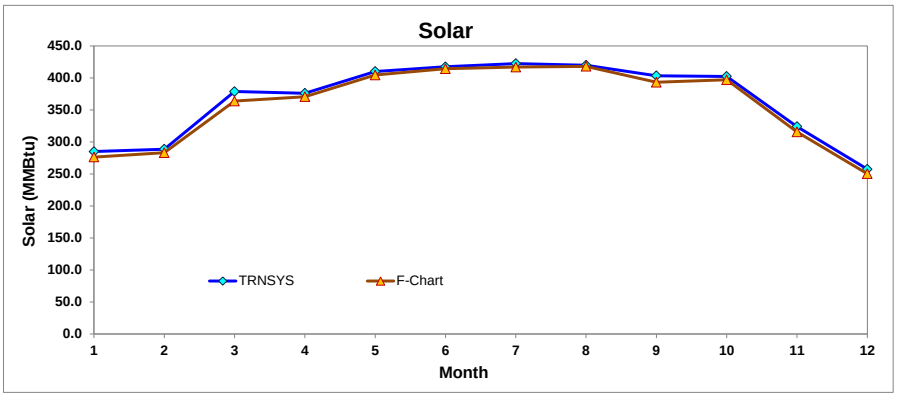


Figure 7-6 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 3 (Ratio=0.93)

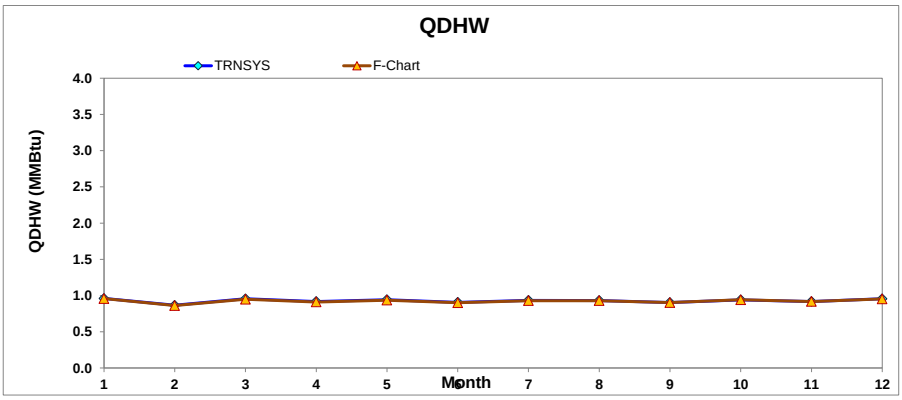


Figure 7-7Monthly Total Water Heating Demand -ANALYSIS 3 (Ratio=0.93)

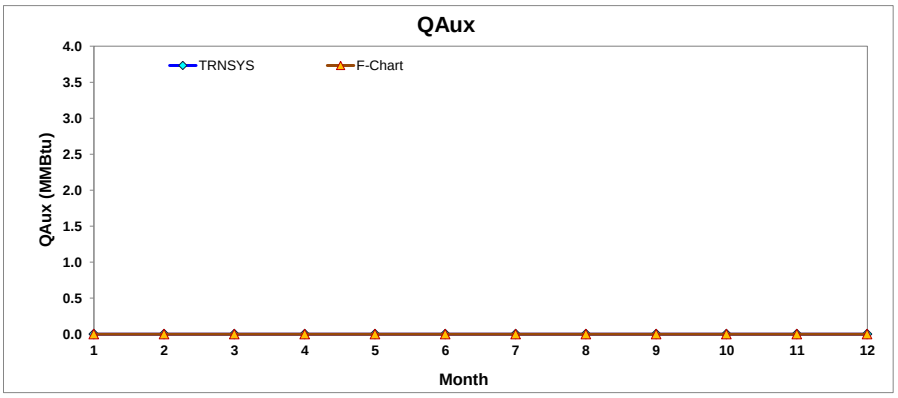


Figure 7-8Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 3 (Ratio=0.93)

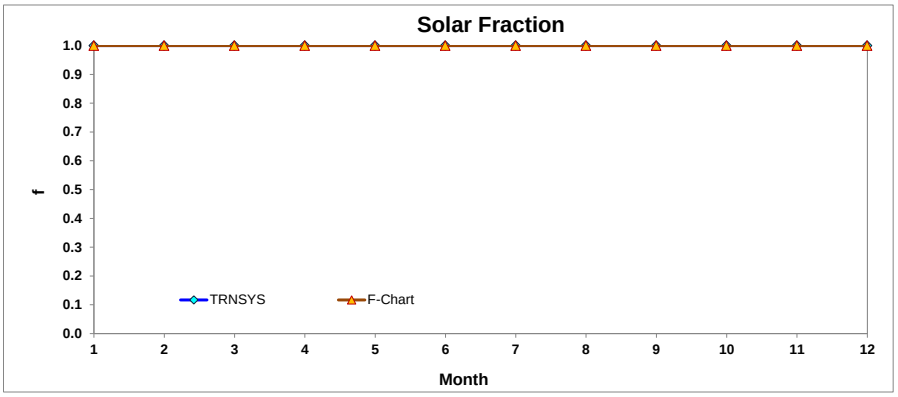


Figure 7-9Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 3 (Ratio=0.93)

Table 7-1 Comparisons Data between TRNSYS and F-Chart ANALYSIS 3 (Ratio=0.93)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	0.961	0.000	1.000	276.400	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	288.769	0.867	0.000	1.000	283.200	0.862	0.000	1.000	-2.0%	0.6%	N/A	0.0%
Mar	378.920	0.955	0.000	1.000	363.900	0.949	0.000	1.000	-4.1%	0.7%	N/A	0.0%
Apr	376.152	0.918	0.000	1.000	370.800	0.911	0.000	1.000	-1.4%	0.8%	N/A	0.0%
May	410.133	0.943	0.000	1.000	404.600	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.579	0.907	0.000	1.000	414.500	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.510	0.934	0.000	1.000	417.000	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	420.044	0.931	0.000	1.000	418.200	0.929	0.000	1.000	-0.4%	0.3%	N/A	0.0%
Sep	403.469	0.904	0.000	1.000	393.300	0.903	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	402.511	0.941	0.000	1.000	397.200	0.942	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	324.088	0.918	0.000	1.000	315.700	0.918	0.000	1.000	-2.7%	0.0%	N/A	0.0%
Dec	257.458	0.955	0.000	1.000	250.300	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	4386.592	11.136	0.000	1.000	4305.200	11.093	0.000	1.000	-1.9%	0.4%	N/A	0.0%

7.3 Analysis 3-Ratio=3

When ratio equals to 3, the storage tank volume is 24000 gallons. The total collector area is 8000 ft^2 and daily hot water usage is still 70 gallons/day.

7.3.1 F-Chart simulation

Figure 7-10 and Figure 7-11 show the input information for F-Chart. The changed settings are presented in a red box. Figure 7-12 gives the result summary of modified simulation.

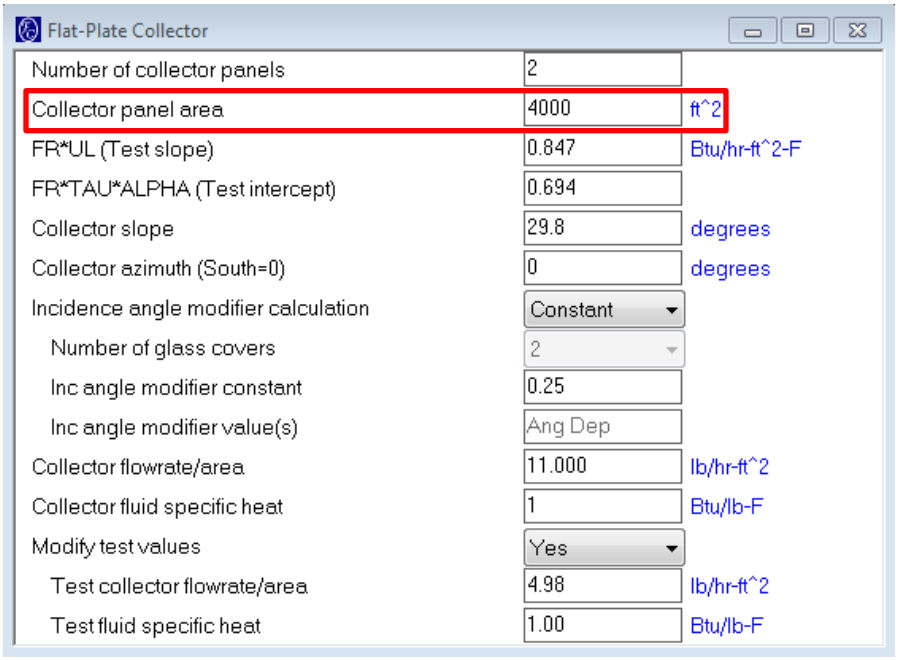


Figure 7-10 Flat-Plate Collector Input

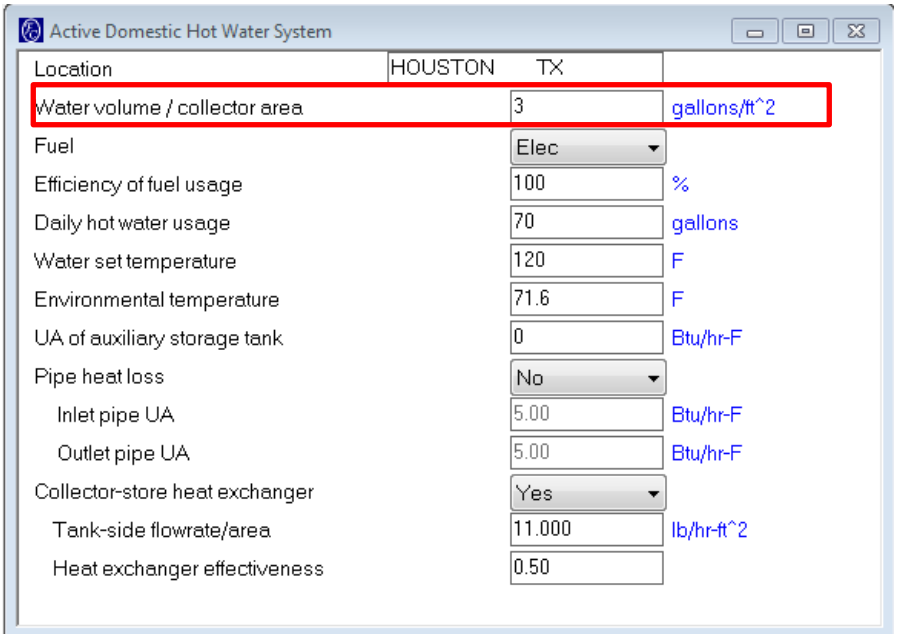
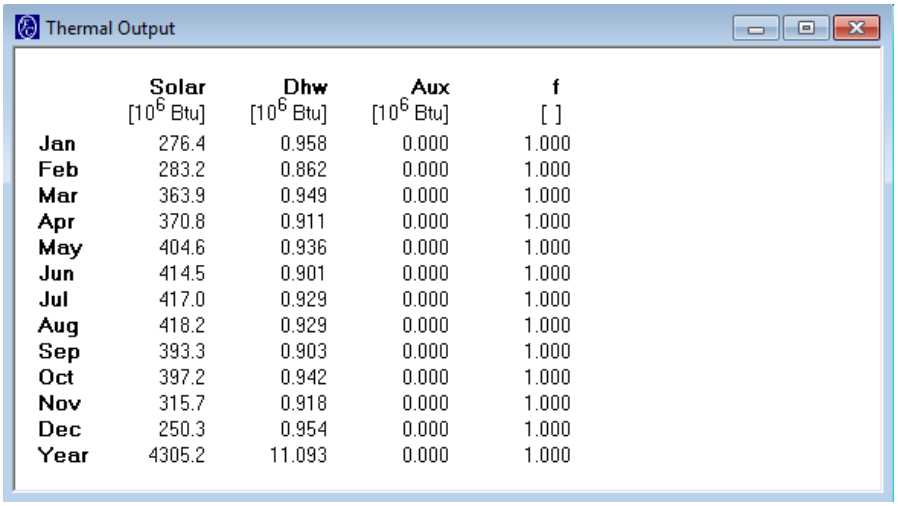


Figure 7-11 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	0.958	0.000	1.000
Feb	283.2	0.862	0.000	1.000
Mar	363.9	0.949	0.000	1.000
Apr	370.8	0.911	0.000	1.000
May	404.6	0.936	0.000	1.000
Jun	414.5	0.901	0.000	1.000
Jul	417.0	0.929	0.000	1.000
Aug	418.2	0.929	0.000	1.000
Sep	393.3	0.903	0.000	1.000
Oct	397.2	0.942	0.000	1.000
Nov	315.7	0.918	0.000	1.000
Dec	250.3	0.954	0.000	1.000
Year	4305.2	11.093	0.000	1.000

Figure 7-12 F-Chart Simulation

7.3.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 7-13 and Figure 7-14.

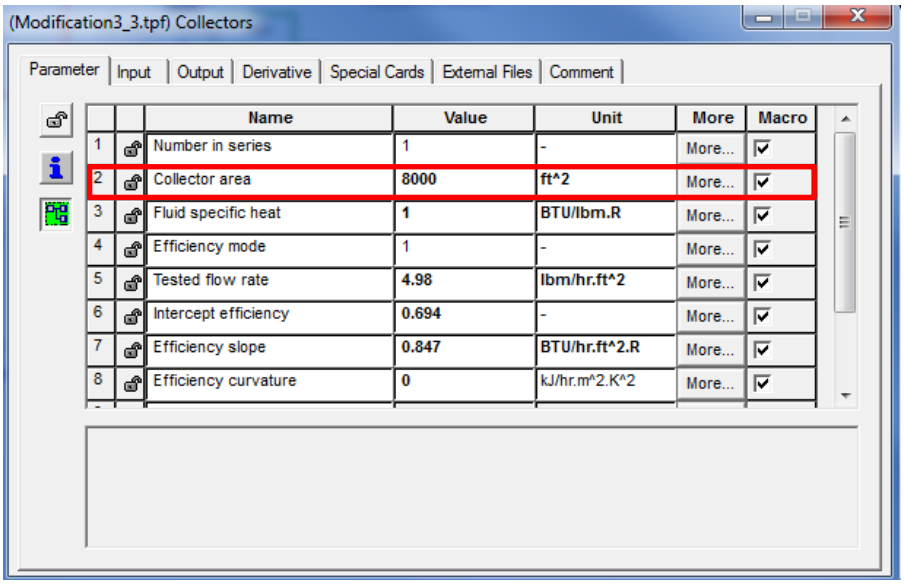


Figure 7-13 TRNSYS Component "Collectors" Settings

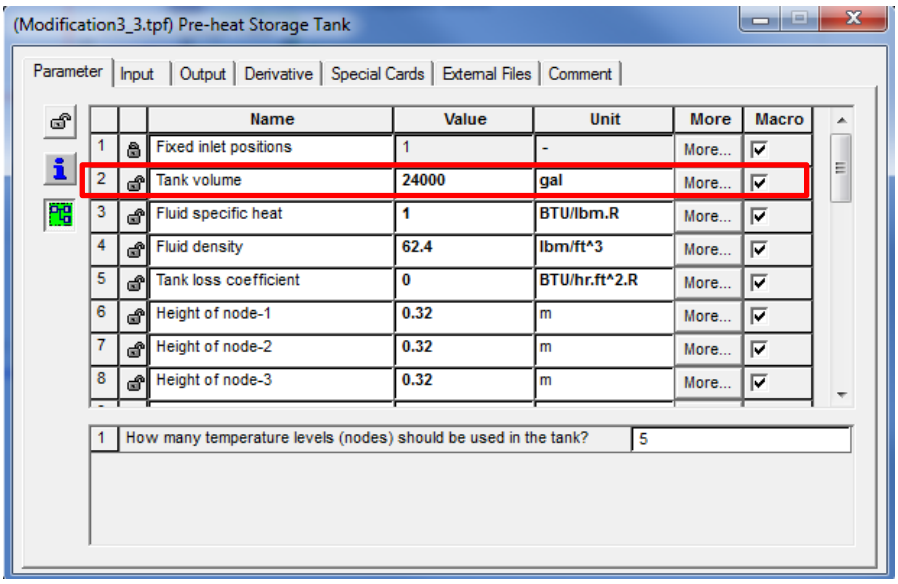


Figure 7-14 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 7-15 - Figure 7-18 present the simulation comparisons for ANALYSIS 1 (ratio=3) including Solar, Dhw, Aux and f factor. In Table 7-2 , Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

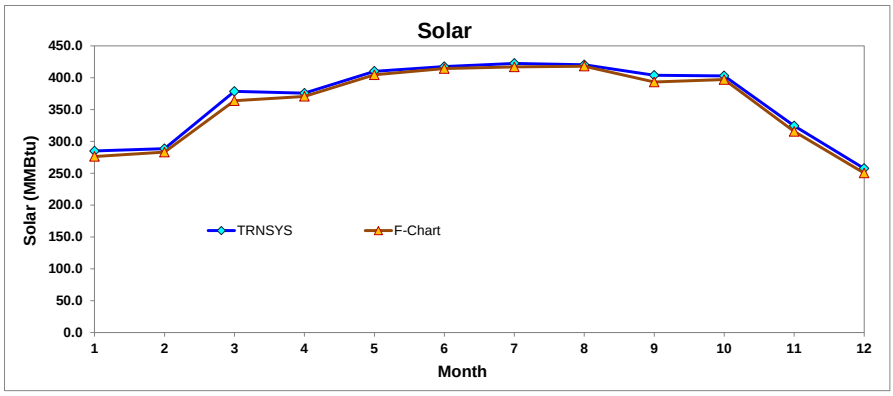


Figure 7-15 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 3 (Ratio=3)

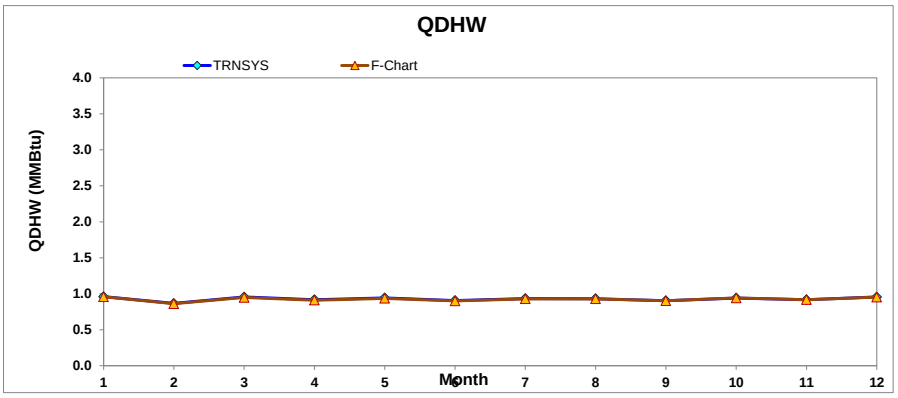


Figure 7-16Monthly Total Water Heating Demand -ANALYSIS 3 (Ratio=3)

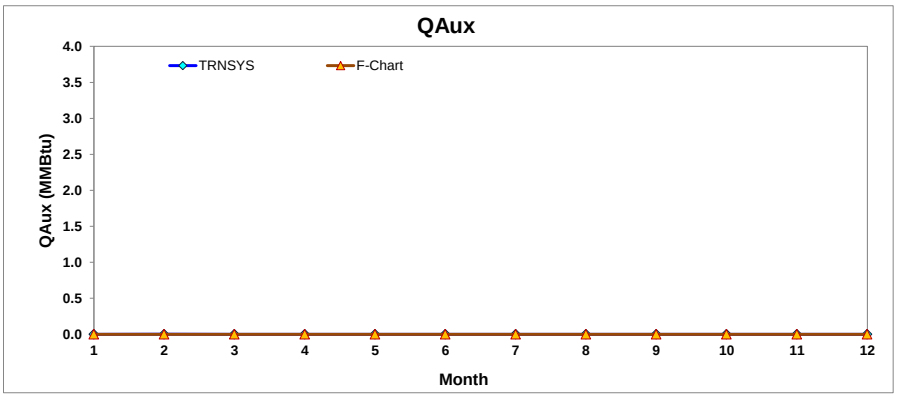


Figure 7-17Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 3 (Ratio=3)

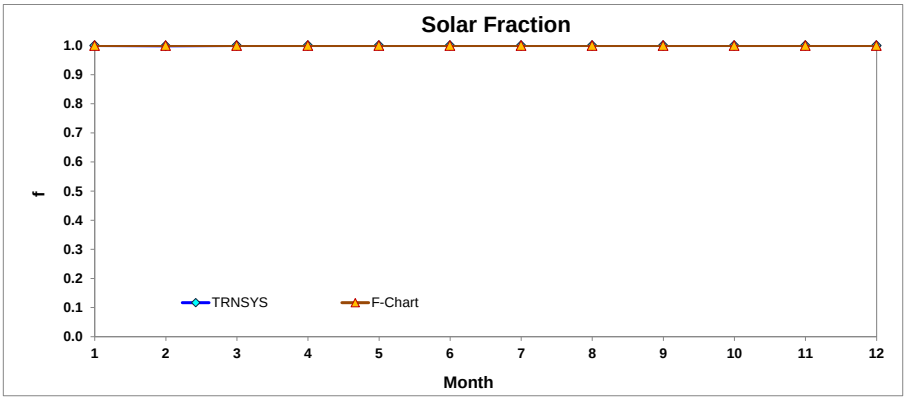


Figure 7-18Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 3 (Ratio=3)

Table 7-2 Comparisons Data between TRNSYS and F-Chart ANALYSIS 3 (Ratio=3)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	0.961	0.000	1.000	276.400	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	288.558	0.867	0.001	0.999	283.200	0.862	0.000	1.000	-1.9%	0.6%	N/A	0.1%
Mar	378.561	0.955	0.000	1.000	363.900	0.949	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	375.729	0.918	0.000	1.000	370.800	0.911	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	410.133	0.943	0.000	1.000	404.600	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.508	0.907	0.000	1.000	414.500	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.580	0.934	0.000	1.000	417.000	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	420.326	0.931	0.000	1.000	418.200	0.929	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	403.892	0.904	0.000	1.000	393.300	0.903	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	403.004	0.941	0.000	1.000	397.200	0.942	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	324.518	0.918	0.000	1.000	315.700	0.918	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	257.535	0.955	0.000	1.000	250.300	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	4387.304	11.136	0.001	1.000	4305.200	11.093	0.000	1.000	-1.9%	0.4%	N/A	0.0%

7.4 Analysis 3-Ratio=5.9

When ratio equals to 5.9, the storage tank volume is 47200 gallons. The total collector area is 8000 ft^2 and daily hot water usage is still 70 gallons/day.

7.4.1 F-Chart simulation

Figure 7-19 and Figure 7-20 show the input information for F-Chart. The changed settings are presented in a red box. Figure 7-21 gives the result summary of modified simulation.

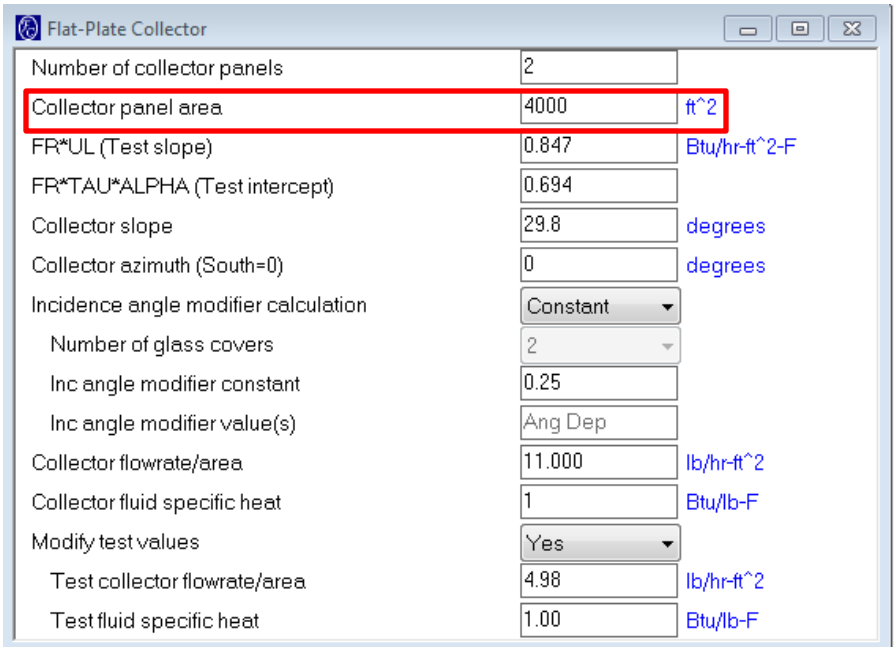


Figure 7-19 Flat-Plate Collector Input

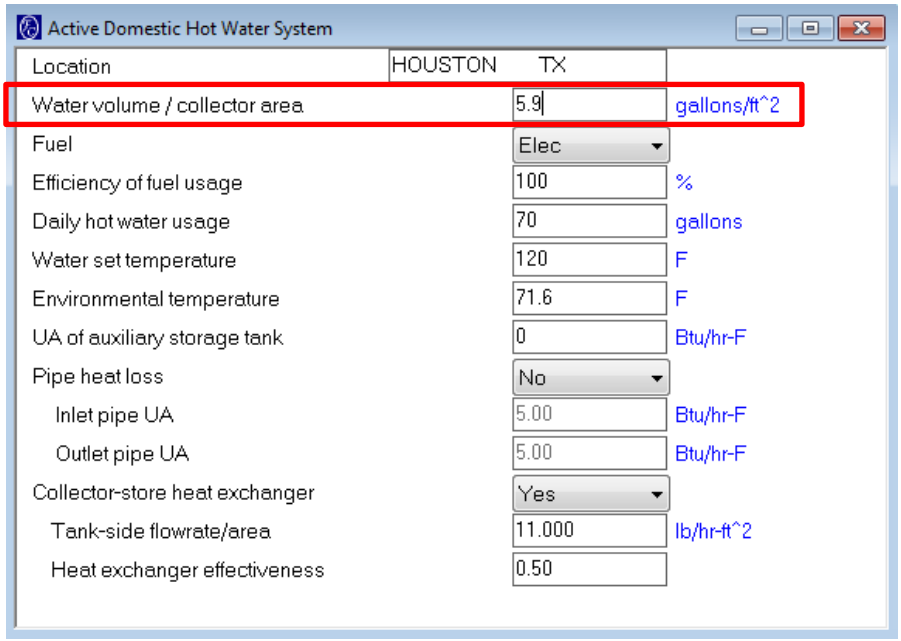
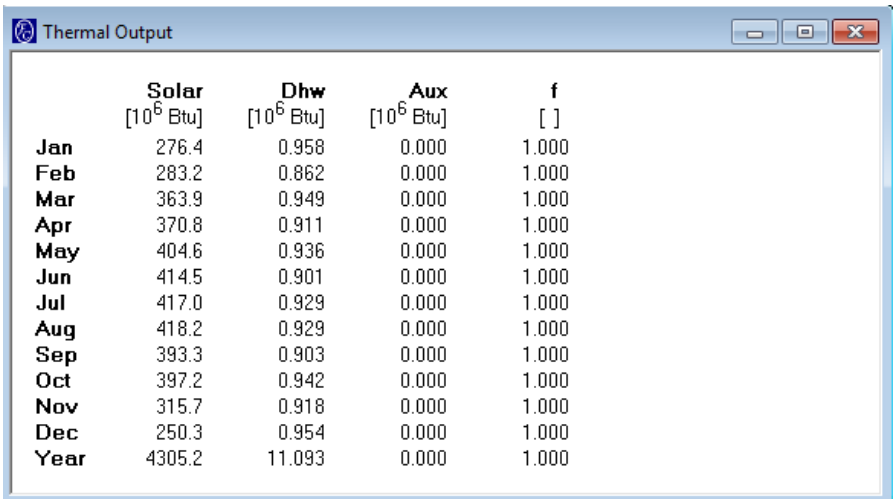


Figure 7-20 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	0.958	0.000	1.000
Feb	283.2	0.862	0.000	1.000
Mar	363.9	0.949	0.000	1.000
Apr	370.8	0.911	0.000	1.000
May	404.6	0.936	0.000	1.000
Jun	414.5	0.901	0.000	1.000
Jul	417.0	0.929	0.000	1.000
Aug	418.2	0.929	0.000	1.000
Sep	393.3	0.903	0.000	1.000
Oct	397.2	0.942	0.000	1.000
Nov	315.7	0.918	0.000	1.000
Dec	250.3	0.954	0.000	1.000
Year	4305.2	11.093	0.000	1.000

Figure 7-21 F-Chart Simulation

7.4.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 7-22 and Figure 7-23.

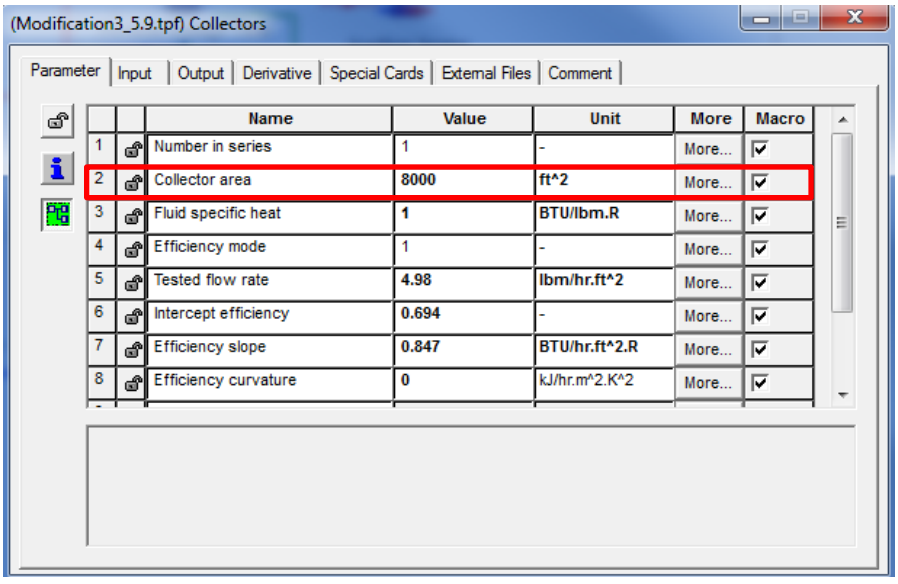


Figure 7-22 TRNSYS Component “Collectors” Settings

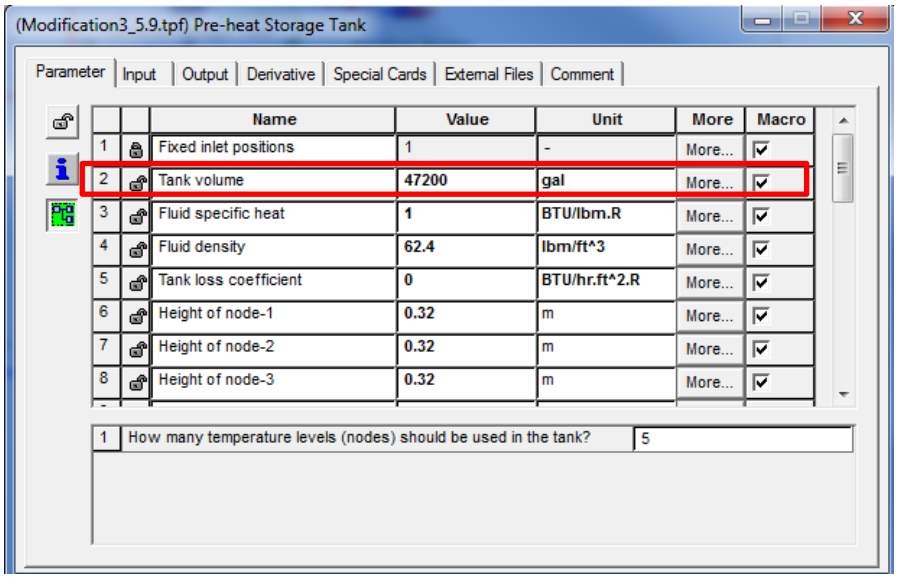


Figure 7-23 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 7-24 - Figure 7-27 present the simulation comparisons for ANALYSIS 1 (ratio=5.9) including Solar, Dhw, Aux and f factor. In Table 7-3, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0%, respectively.

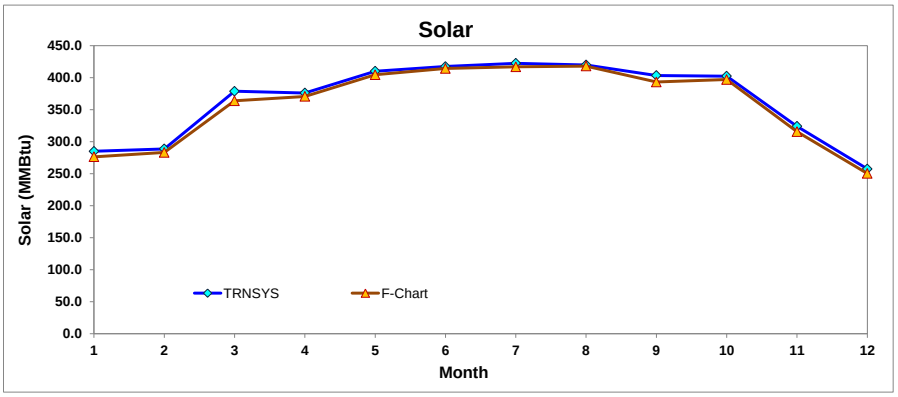


Figure 7-24 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 3 (Ratio=5.9)

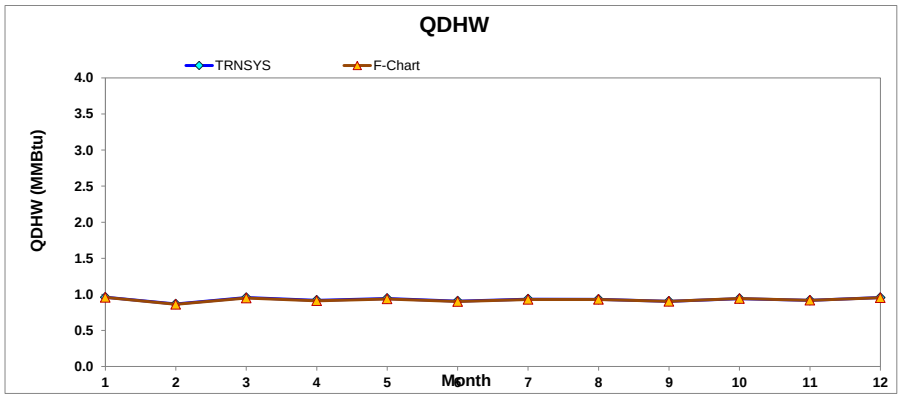


Figure 7-25Monthly Total Water Heating Demand -ANALYSIS 3 (Ratio=5.9)

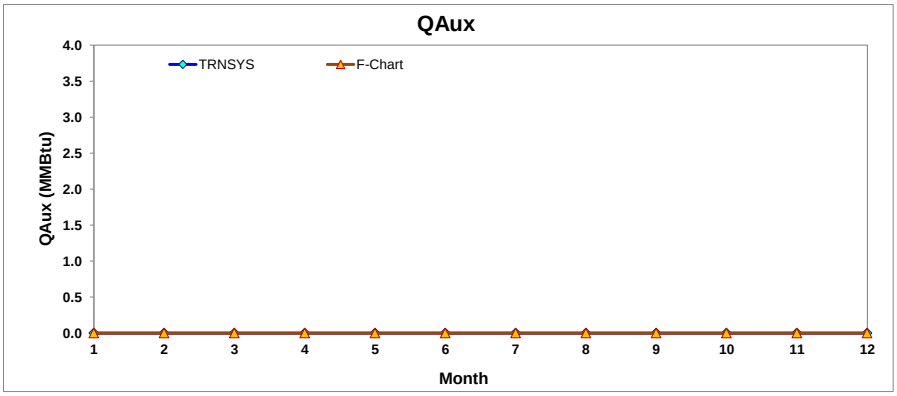


Figure 7-26Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 3 (Ratio=5.9)

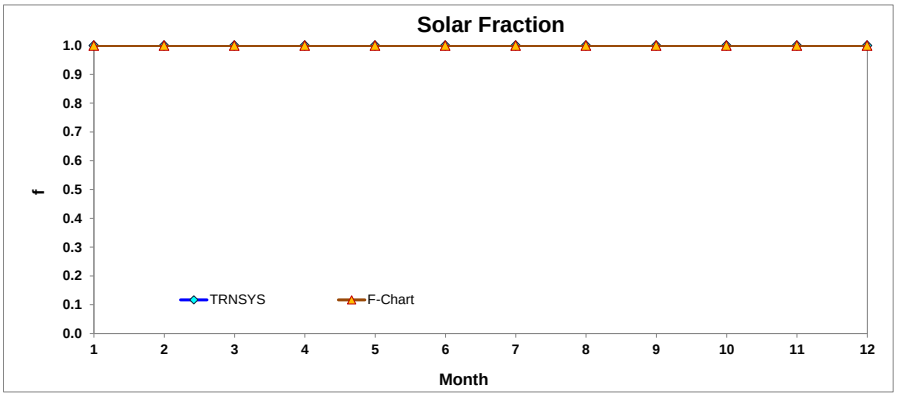


Figure 7-27Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 3 (Ratio=5.9)

Table 7-3 Comparisons Data between TRNSYS and F-Chart ANALYSIS 3 (Ratio=5.9)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	0.961	0.000	1.000	276.400	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	288.769	0.867	0.000	1.000	283.200	0.862	0.000	1.000	-2.0%	0.6%	N/A	0.0%
Mar	378.920	0.955	0.000	1.000	363.900	0.949	0.000	1.000	-4.1%	0.7%	N/A	0.0%
Apr	376.152	0.918	0.000	1.000	370.800	0.911	0.000	1.000	-1.4%	0.8%	N/A	0.0%
May	410.133	0.943	0.000	1.000	404.600	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.579	0.907	0.000	1.000	414.500	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.510	0.934	0.000	1.000	417.000	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	420.044	0.931	0.000	1.000	418.200	0.929	0.000	1.000	-0.4%	0.3%	N/A	0.0%
Sep	403.469	0.904	0.000	1.000	393.300	0.903	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	402.511	0.941	0.000	1.000	397.200	0.942	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	324.088	0.918	0.000	1.000	315.700	0.918	0.000	1.000	-2.7%	0.0%	N/A	0.0%
Dec	257.458	0.955	0.000	1.000	250.300	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	4386.592	11.136	0.000	1.000	4305.200	11.093	0.000	1.000	-1.9%	0.4%	N/A	0.0%

7.5 Analysis 3-Ratio=7.3

When ratio equals to 7.3, the storage tank volume is 58400 gallons. The total collector area is 8000 ft^2 and daily hot water usage is still 70 gallons/day.

7.5.1 F-Chart simulation

Figure 7-28 and Figure 7-29 show the input information for F-Chart. The changed settings are presented in a red box. Figure 7-30 gives the result summary of modified simulation.

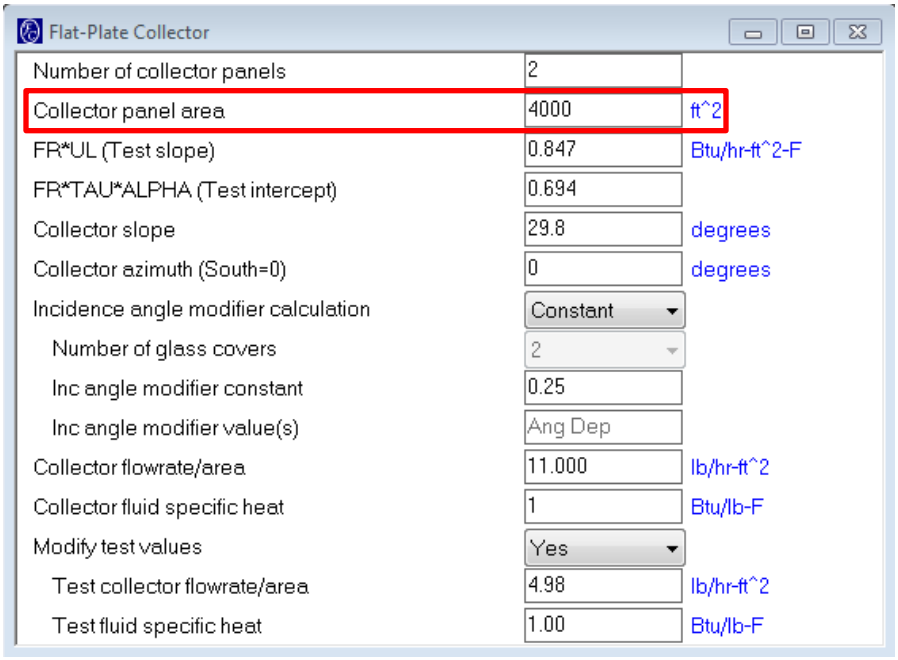


Figure 7-28 Flat-Plate Collector Input

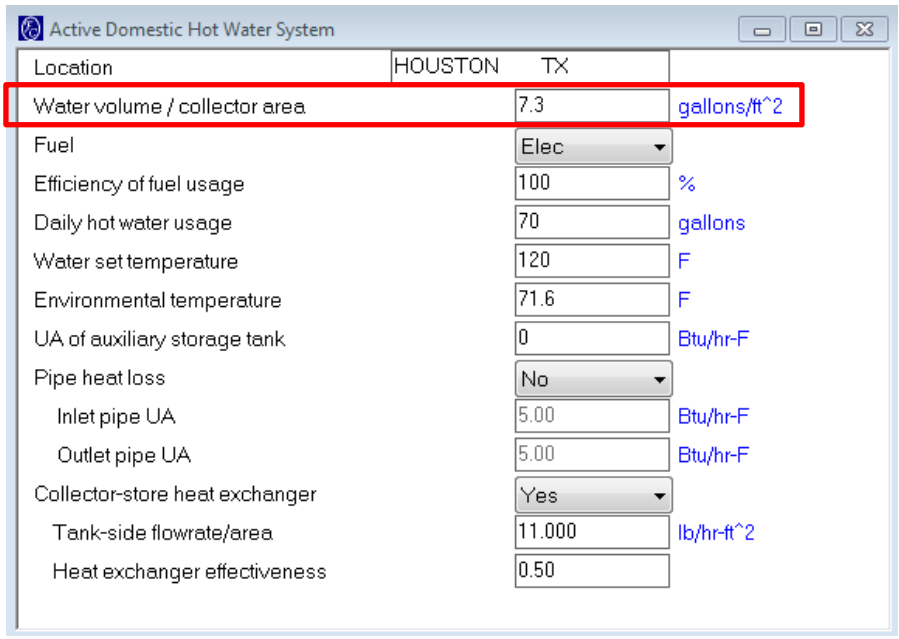
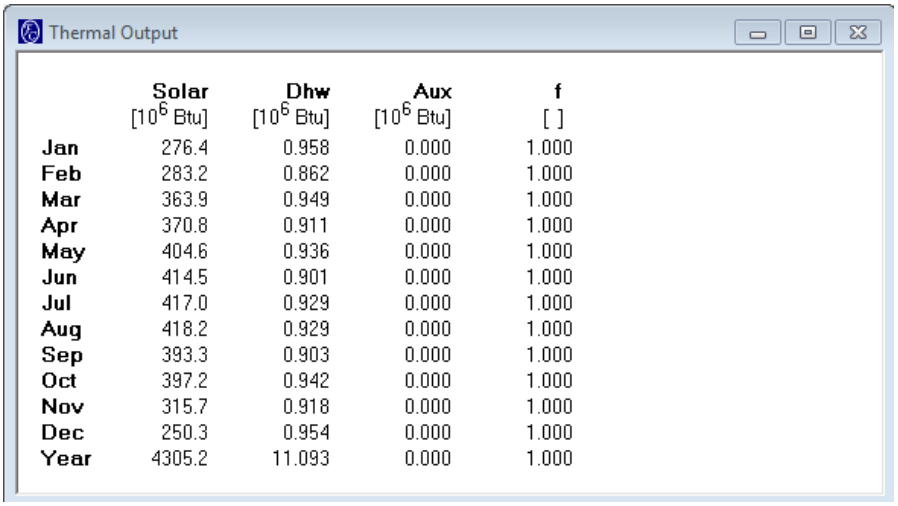


Figure 7-29 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	0.958	0.000	1.000
Feb	283.2	0.862	0.000	1.000
Mar	363.9	0.949	0.000	1.000
Apr	370.8	0.911	0.000	1.000
May	404.6	0.936	0.000	1.000
Jun	414.5	0.901	0.000	1.000
Jul	417.0	0.929	0.000	1.000
Aug	418.2	0.929	0.000	1.000
Sep	393.3	0.903	0.000	1.000
Oct	397.2	0.942	0.000	1.000
Nov	315.7	0.918	0.000	1.000
Dec	250.3	0.954	0.000	1.000
Year	4305.2	11.093	0.000	1.000

Figure 7-30 F-Chart Simulation

7.5.2 TRSNYS simulation

The TRNSYS components “Collectors” and “Pre-heat Storage tank” settings are updated. The changed areas are marked by red boxed, seen in Figure 7-31 and Figure 7-32.

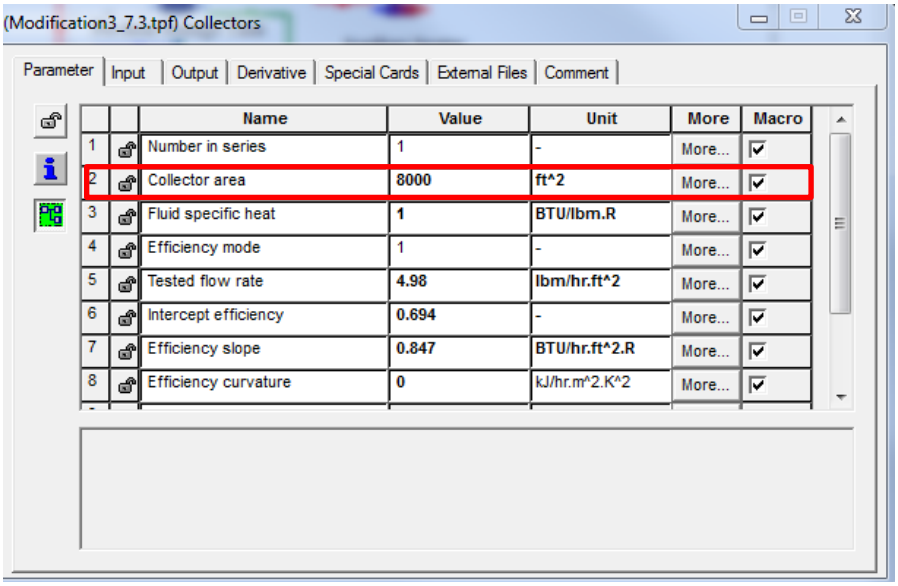


Figure 7-31 TRNSYS Component "Collectors" Settings

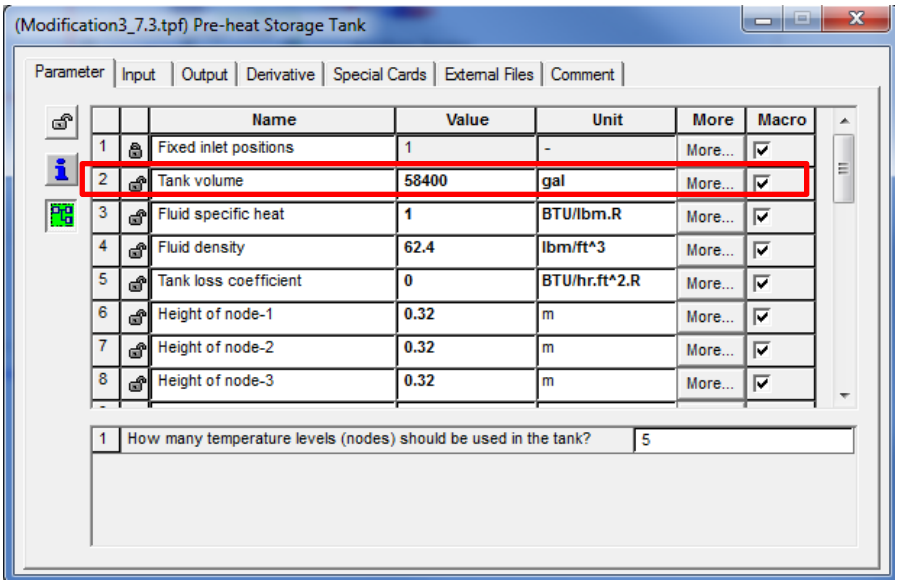


Figure 7-32 TRNSYS Component "Pre-heat Storage tank" Settings

Figure 7-33 - Figure 6-36 present the simulation comparisons for ANALYSIS 3 (ratio=7.3) including Solar, Dhw, Aux and f factor. In Table 7-4, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 1.4%, respectively.

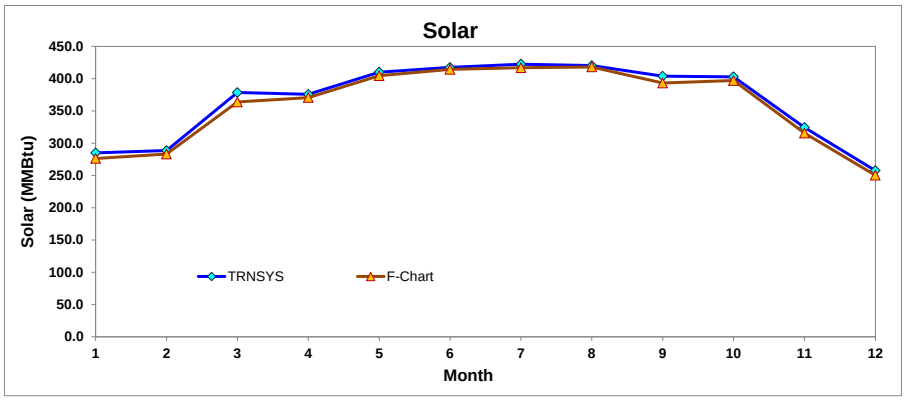


Figure 7-33 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 3 (Ratio=7.3)

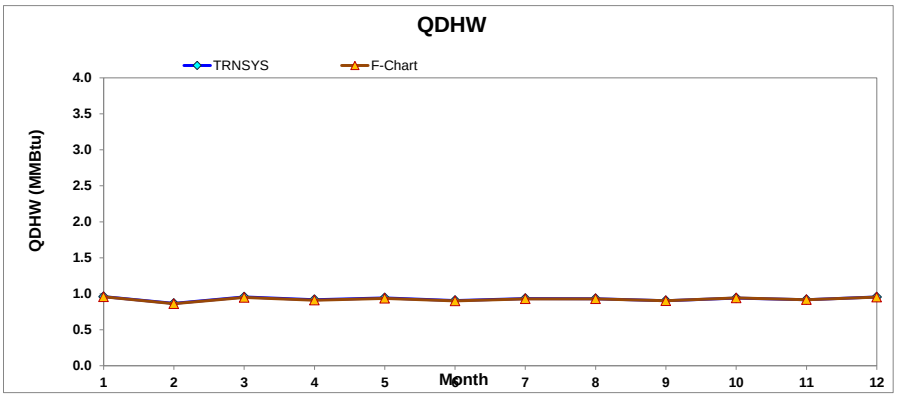


Figure 7-34Monthly Total Water Heating Demand -ANALYSIS 3 (Ratio=7.3)

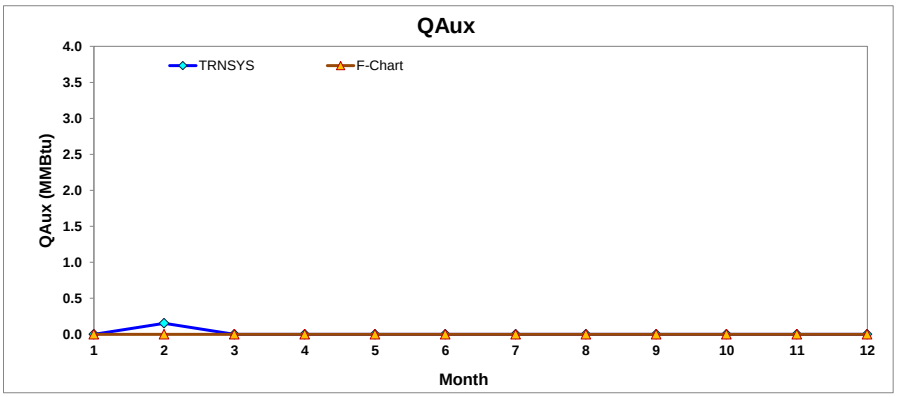


Figure 7-35Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 3 (Ratio=7.3)

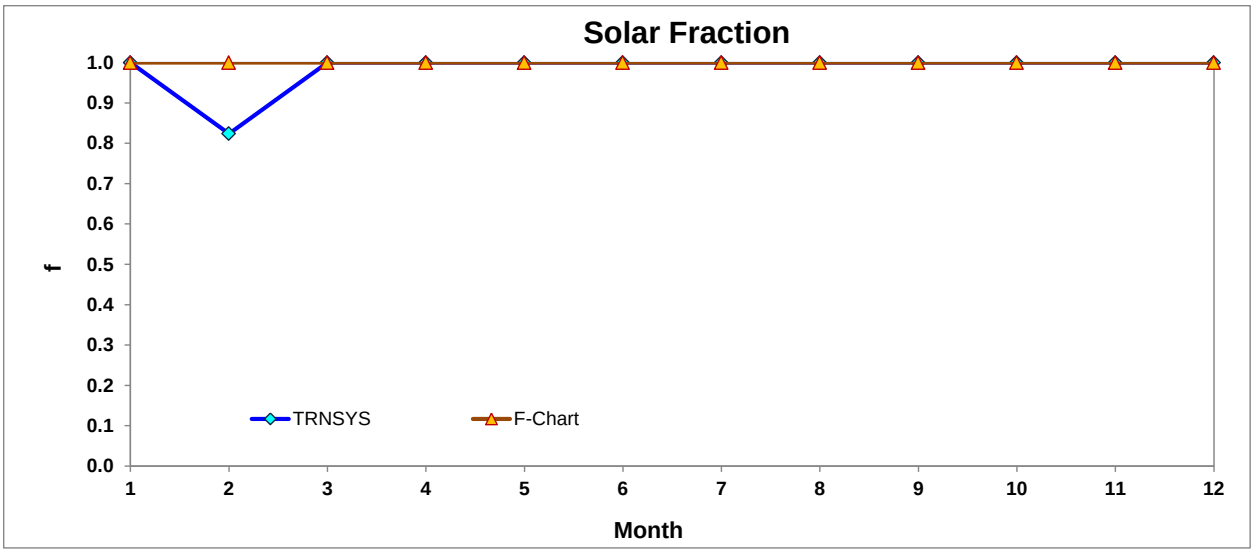


Figure 7-36 Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 3 (Ratio=7.3)

Table 7-4 Comparisons Data between TRNSYS and F-Chart ANALYSIS 3 (Ratio=7.3)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	0.961	0.000	1.000	276.400	0.958	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	288.558	0.867	0.153	0.824	283.200	0.862	0.000	1.000	-1.9%	0.6%	N/A	17.6%
Mar	378.561	0.955	0.000	1.000	363.900	0.949	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	375.729	0.918	0.000	1.000	370.800	0.911	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	410.133	0.943	0.000	1.000	404.600	0.936	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.508	0.907	0.000	1.000	414.500	0.901	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.580	0.934	0.000	1.000	417.000	0.929	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	420.326	0.931	0.000	1.000	418.200	0.929	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	403.892	0.904	0.000	1.000	393.300	0.903	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	403.004	0.941	0.000	1.000	397.200	0.942	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	324.518	0.918	0.000	1.000	315.700	0.918	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	257.535	0.955	0.000	1.000	250.300	0.954	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	4387.304	11.136	0.153	0.986	4305.200	11.093	0.000	1.000	-1.9%	0.4%	N/A	1.4%

7.6 Discussion

Figure 7-37 compares the f factor of SDHW system simulated by TRNSYS and F-Chart. It has shown that both results follow similar pattern and trend. Except the ratio=7.3, the f factor simulated by TRNSYS decreases as water volume/collector area ratio increases. This is because the storage tank volume is so large that it cannot well support the hot water demand.

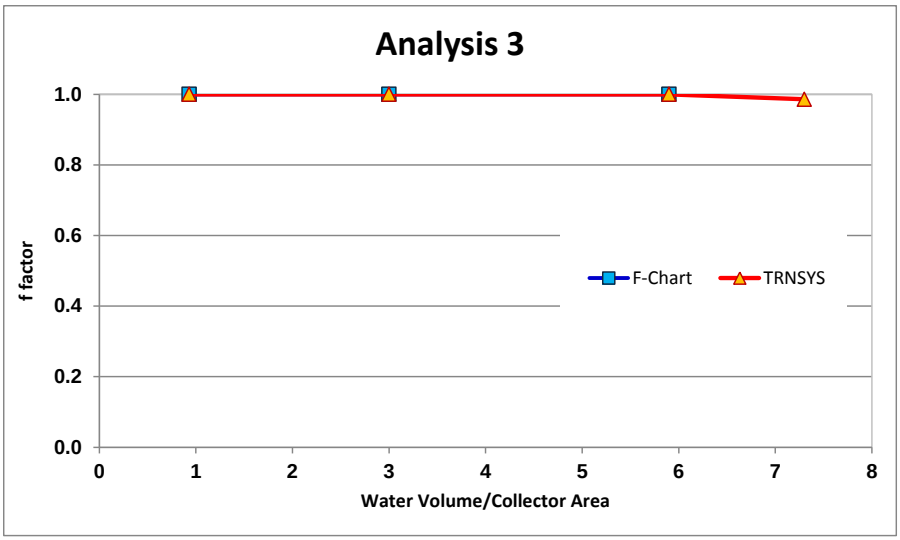


Figure 7-37 f Factor Comparisons between F-Chart and TRNSYS – ANALYSIS 3

8 SOLAR DOMESTIC HOT WATER SYSTEM SIMULATION COMPARISONS OF ANALYSIS 4 – DAILY HOT WATER USAGE STUDY PART I

8.1 Overview

Starting from this section, different case studies are performed to further checking the simulation accuracy of TRNSYS program on SDHW System. This section will vary the total collector area from 64.02 ft^2 to 80 ft^2. With 80ft^2 total solar collector area, the daily hot water usage is varied by 50,51,55,85,106,107 and 115 gallons/day. The other settings are kept as the same as base case.

8.2 ANALYSIS 4-50 Gallons/Day

The total collector area is 80 ft^2 and daily hot water usage is 50 gallons/day with the storage tank volume 94.88 gallons.

8.2.1 F-Chart simulation

Figure 8-1 and Figure 8-2 show the input information for F-Chart. The changed settings are presented in a red box. Figure 8-3 gives the result summary of modified simulation.

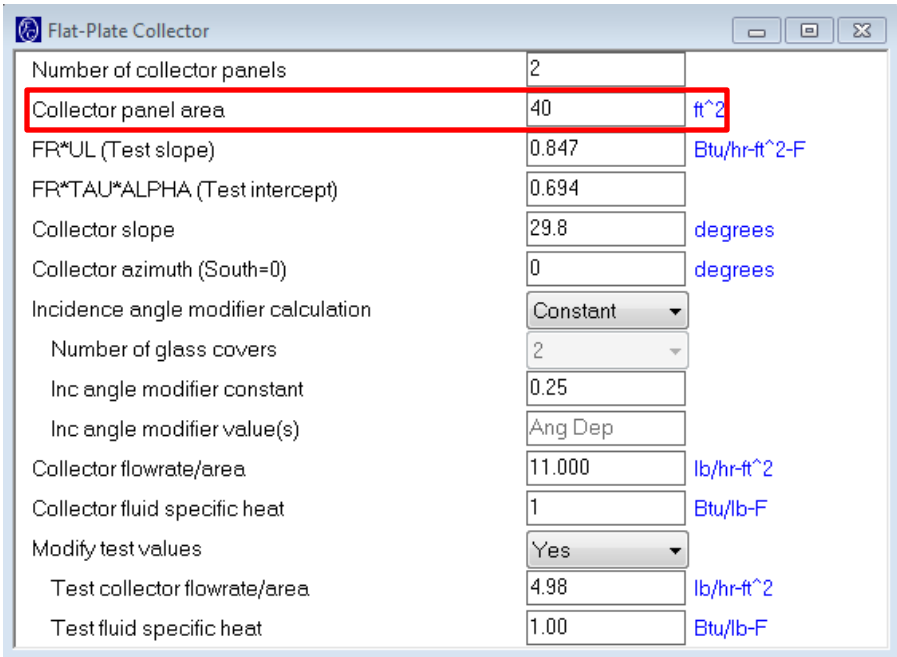


Figure 8-1 Flat-Plate Collector Input

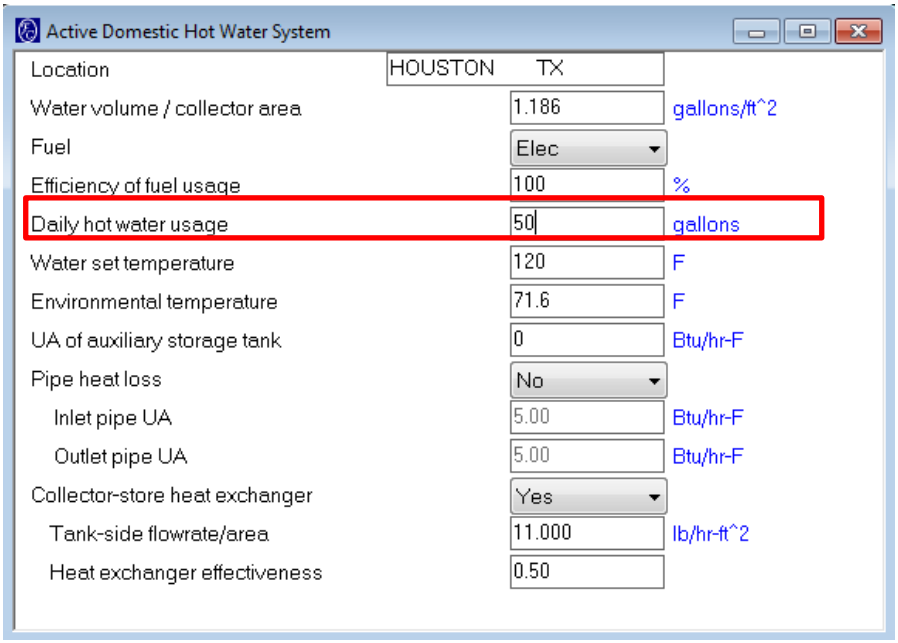
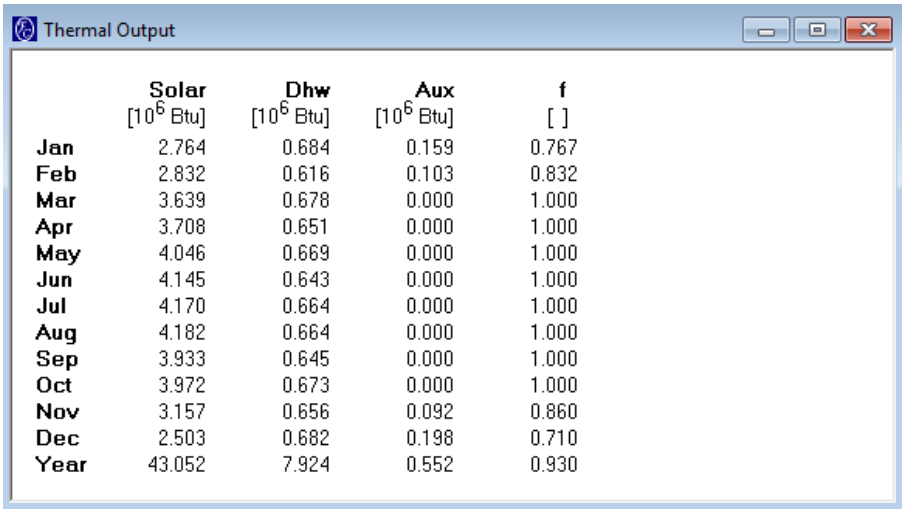


Figure 8-2 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	0.684	0.159	0.767
Feb	2.832	0.616	0.103	0.832
Mar	3.639	0.678	0.000	1.000
Apr	3.708	0.651	0.000	1.000
May	4.046	0.669	0.000	1.000
Jun	4.145	0.643	0.000	1.000
Jul	4.170	0.664	0.000	1.000
Aug	4.182	0.664	0.000	1.000
Sep	3.933	0.645	0.000	1.000
Oct	3.972	0.673	0.000	1.000
Nov	3.157	0.656	0.092	0.860
Dec	2.503	0.682	0.198	0.710
Year	43.052	7.924	0.552	0.930

Figure 8-3 F-Chart Simulation

8.2.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 8-4, Figure 8-5 and Figure 8-6.

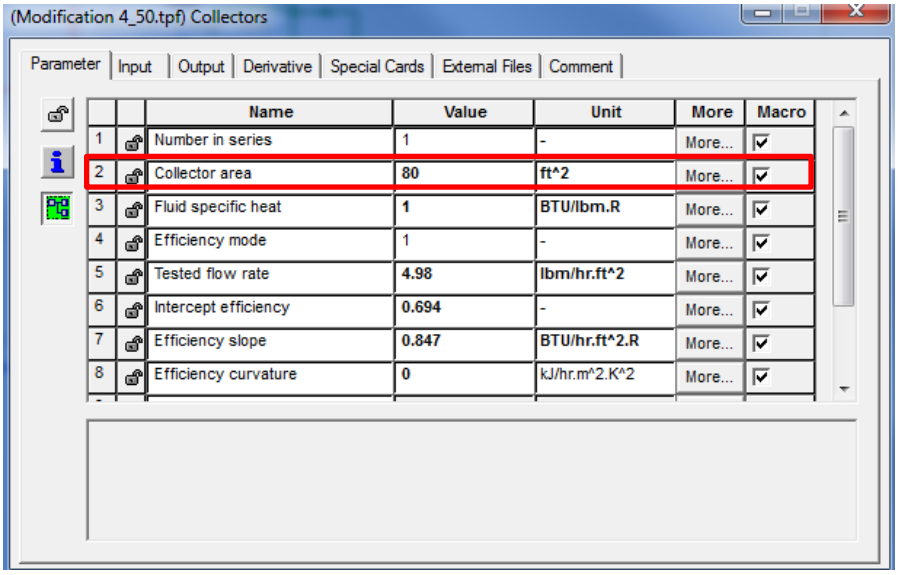


Figure 8-4 TRNSYS Component “Collectors” Settings

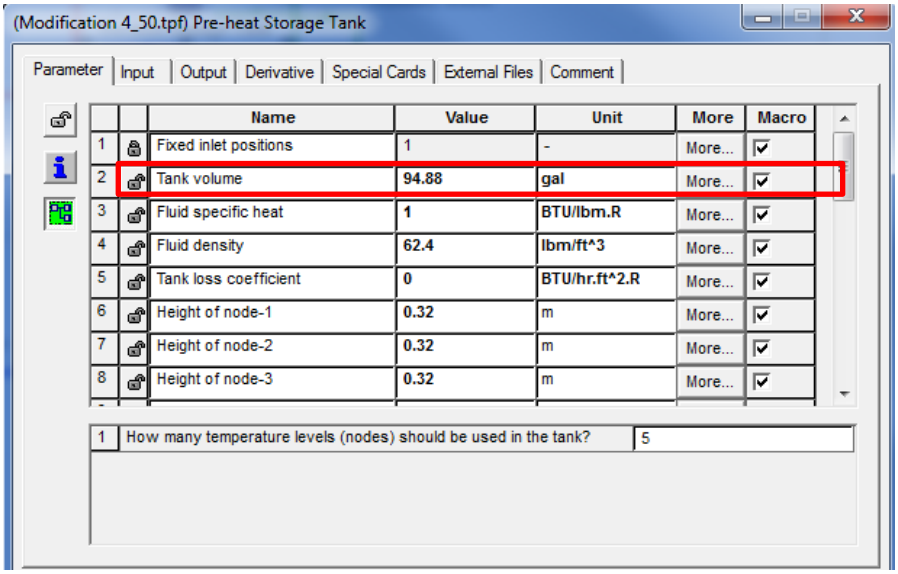


Figure 8-5 TRNSYS Component "Pre-heat Storage tank" Settings

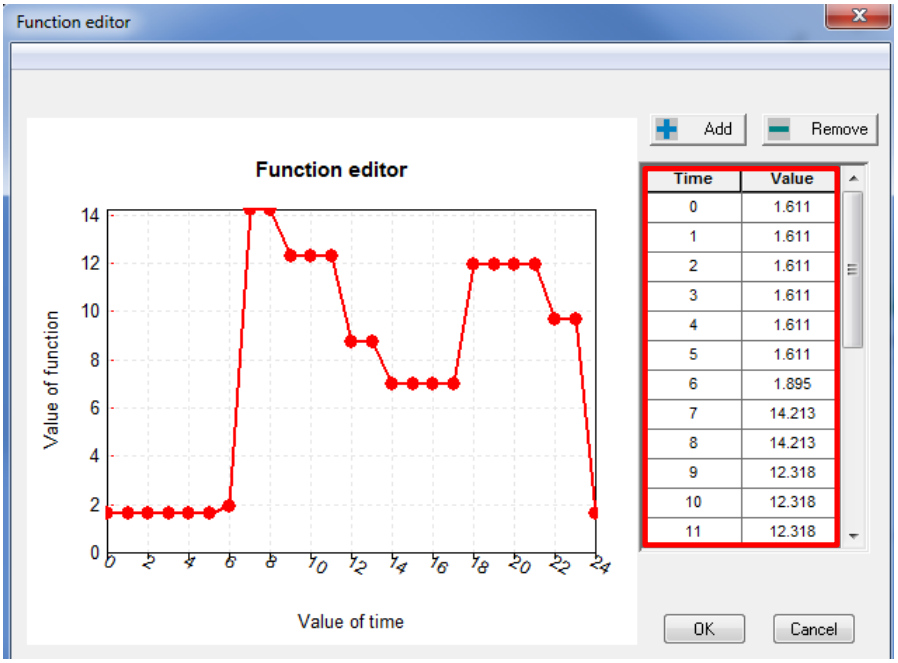


Figure 8-6 TRNSYS Component "Hot Water Demand" Settings

Figure 8-7 - Figure 8-10 present the simulation comparisons for ANALYSIS 4 (50 gallons/day) including Solar, Dhw, Aux and f factor. In Table 8-1, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 14.6% and -1.2 %, respectively.

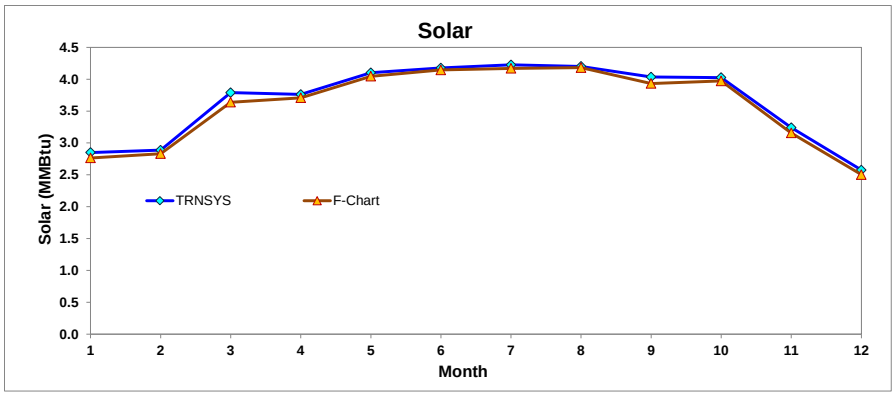


Figure 8-7 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 4 (50 gallons/day)

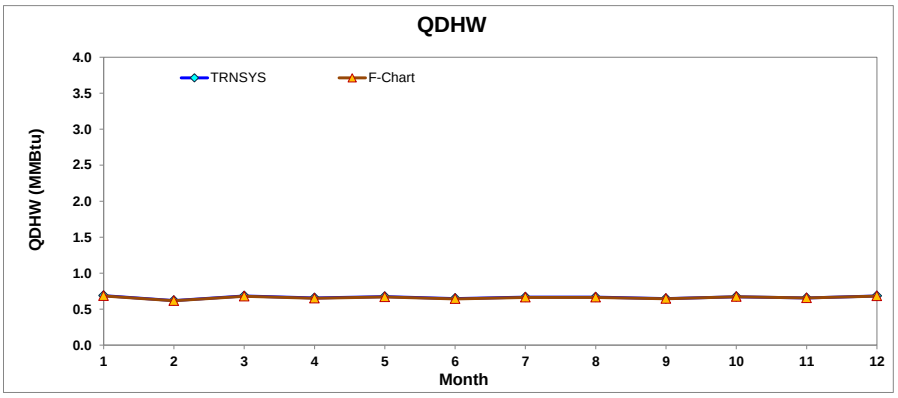


Figure 8-8Monthly Total Water Heating Demand -ANALYSIS 4 (50 gallons/day)

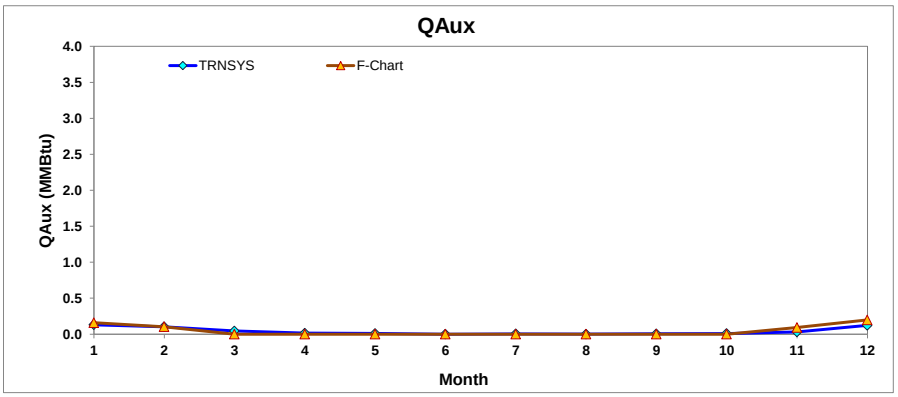


Figure 8-9Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 4 (50 gallons/day)

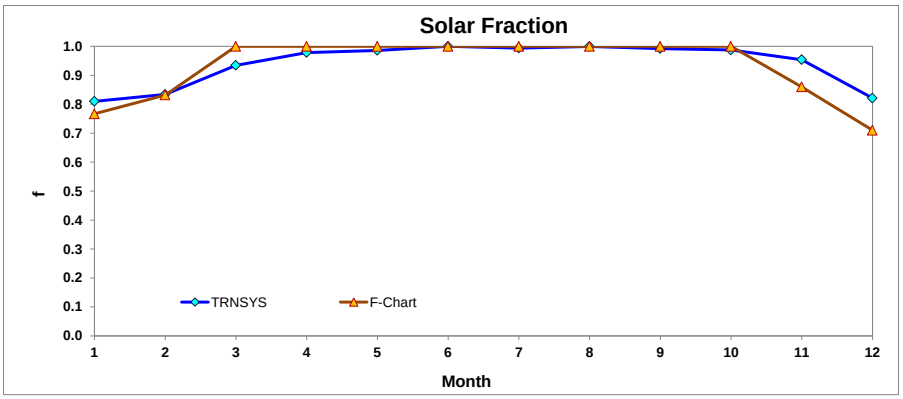


Figure 8-10Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 4 (50 gallons/day)

Table 8-1 Comparisons Data between TRNSYS and F-Chart ANALYSIS 4 (50 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	0.688	0.130	0.810	2.764	0.684	0.159	0.767	-3.1%	-0.5%	18.0%	-5.6%
Feb	2.888	0.619	0.103	0.834	2.832	0.616	0.103	0.832	-2.0%	0.5%	0.1%	-0.2%
Mar	3.789	0.683	0.045	0.935	3.639	0.678	0.000	1.000	-4.1%	0.7%	N/A	6.5%
Apr	3.762	0.656	0.014	0.979	3.708	0.651	0.000	1.000	-1.4%	0.8%	N/A	2.1%
May	4.101	0.674	0.009	0.986	4.046	0.669	0.000	1.000	-1.4%	0.7%	N/A	1.4%
Jun	4.176	0.648	0.000	1.000	4.145	0.643	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	4.225	0.667	0.004	0.994	4.170	0.664	0.000	1.000	-1.3%	0.4%	N/A	0.6%
Aug	4.200	0.667	0.000	1.000	4.182	0.664	0.000	1.000	-0.4%	0.4%	N/A	0.0%
Sep	4.035	0.646	0.005	0.992	3.933	0.645	0.000	1.000	-2.6%	0.1%	N/A	0.8%
Oct	4.025	0.672	0.008	0.987	3.972	0.673	0.000	1.000	-1.3%	0.1%	N/A	1.3%
Nov	3.241	0.656	0.030	0.954	3.157	0.656	0.092	0.860	-2.7%	0.0%	N/A	-10.9%
Dec	2.575	0.683	0.122	0.821	2.503	0.682	0.198	0.710	-2.9%	0.1%	N/A	-15.7%
Year	43.866	7.957	0.471	0.941	43.052	7.924	0.552	0.930	-1.9%	0.4%	14.6%	-1.2%

8.3 ANALYSIS 4-51 Gallons/Day

The total collector area is 80 ft^2 and daily hot water usage is 51 gallons/day with the storage tank volume 94.88 gallons.

8.3.1 F-Chart simulation

Figure 8-11 and Figure 8-12 show the input information for F-Chart. The changed settings are presented in a red box. Figure 8-13 gives the result summary of modified simulation.

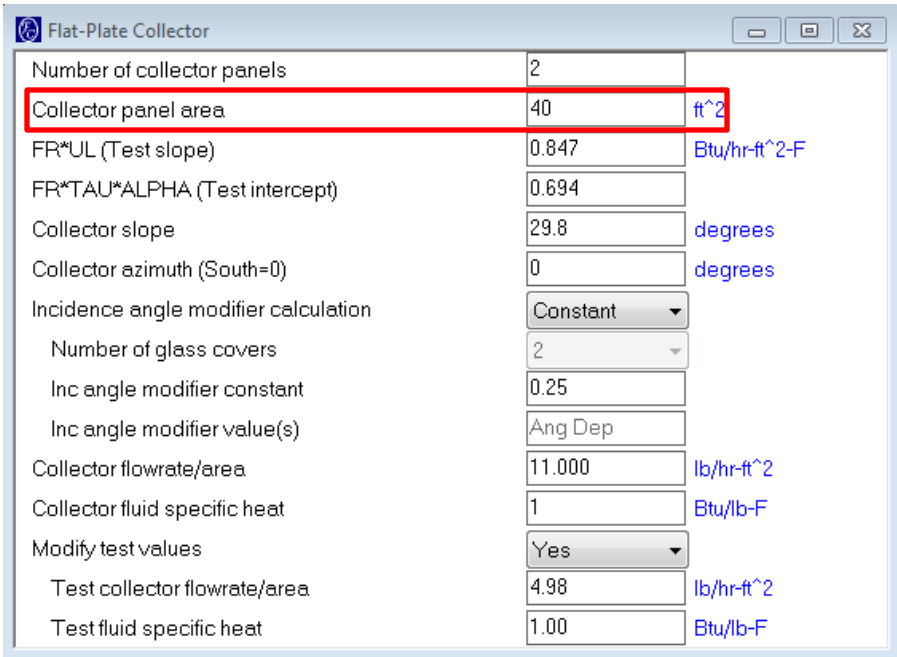


Figure 8-11 Flat-Plate Collector Input

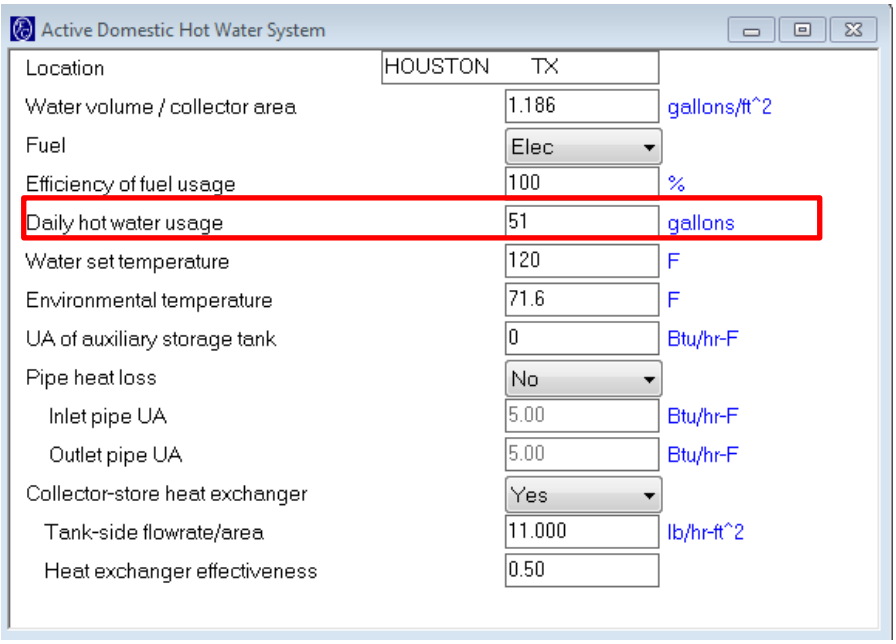
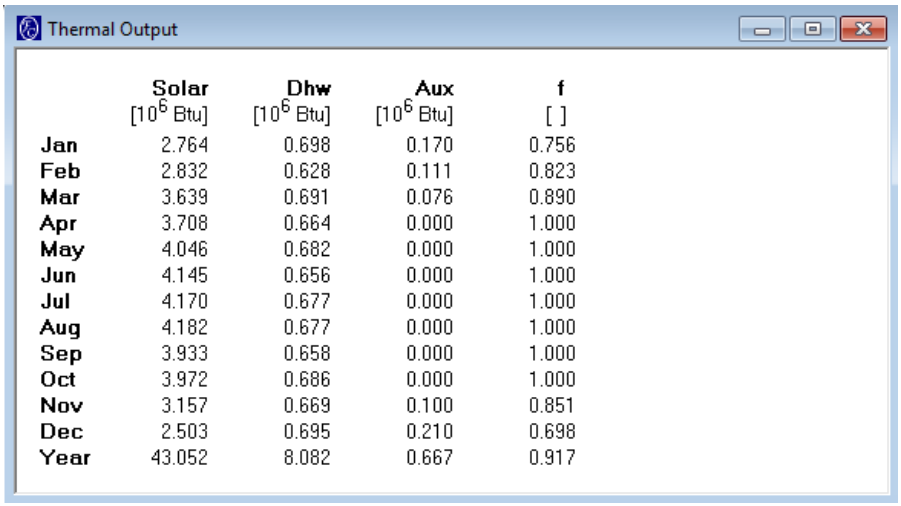


Figure 8-12 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	0.698	0.170	0.756
Feb	2.832	0.628	0.111	0.823
Mar	3.639	0.691	0.076	0.890
Apr	3.708	0.664	0.000	1.000
May	4.046	0.682	0.000	1.000
Jun	4.145	0.656	0.000	1.000
Jul	4.170	0.677	0.000	1.000
Aug	4.182	0.677	0.000	1.000
Sep	3.933	0.658	0.000	1.000
Oct	3.972	0.686	0.000	1.000
Nov	3.157	0.669	0.100	0.851
Dec	2.503	0.695	0.210	0.698
Year	43.052	8.082	0.667	0.917

Figure 8-13 F-Chart Simulation

8.3.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 8-14 , Figure 8-15 and Figure 8-16.

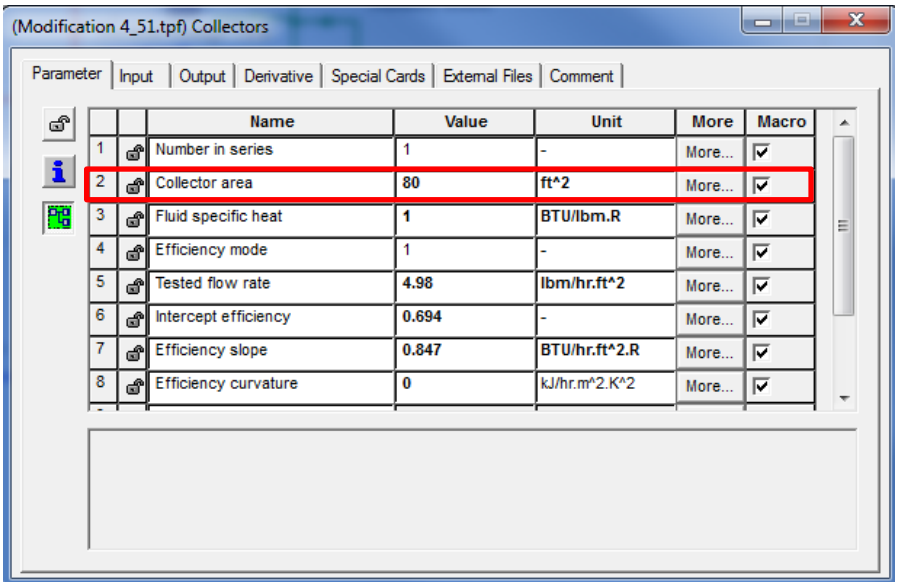


Figure 8-14 TRNSYS Component “Collectors” Settings

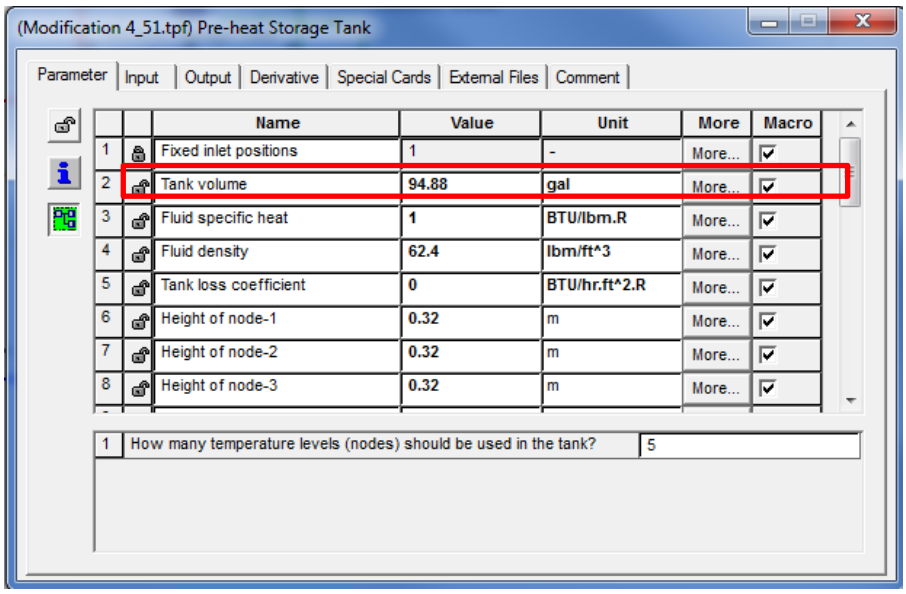


Figure 8-15 TRNSYS Component "Pre-heat Storage tank" Settings

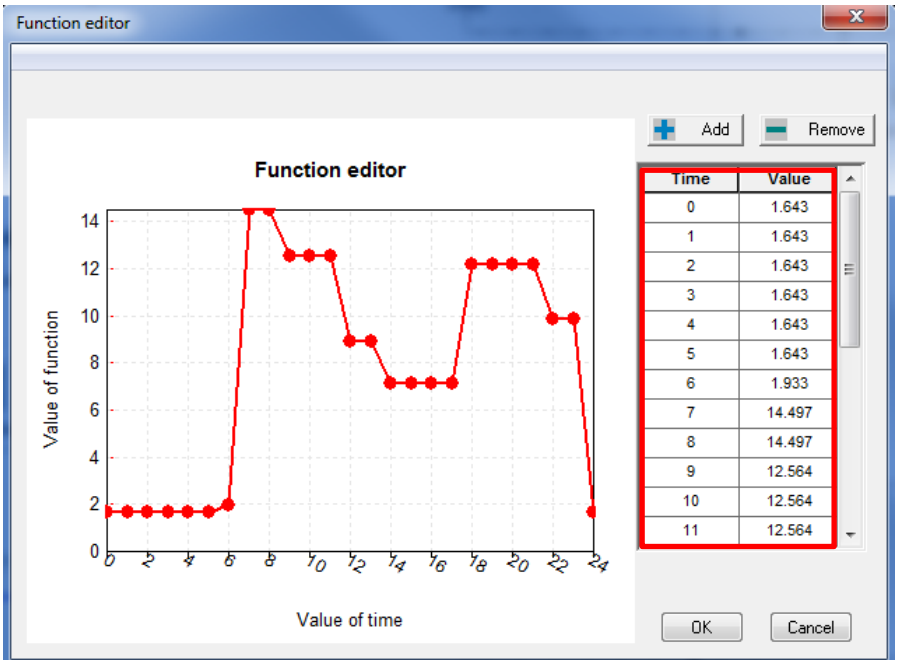


Figure 8-16 TRNSYS Component "Hot Water Demand" Settings

Figure 8-17 - Figure 8-20 present the simulation comparisons for ANALYSIS 4 (51 gallons/day) including Solar, Dhw, Aux and f factor. In Table 8-2, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 25.3% and -2.4 %, respectively.

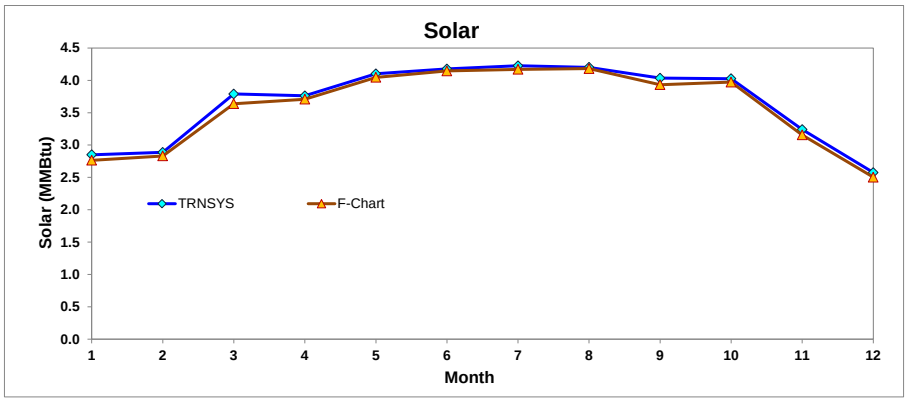


Figure 8-17 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 4 (51 gallons/day)

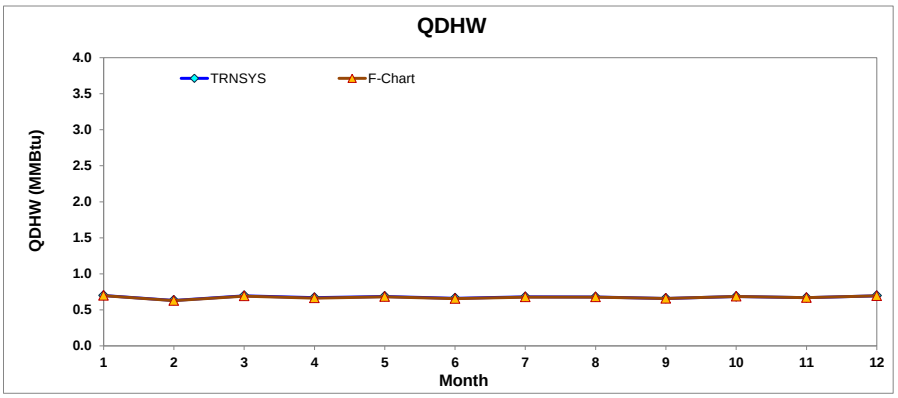


Figure 8-18Monthly Total Water Heating Demand -ANALYSIS 4 (51 gallons/day)

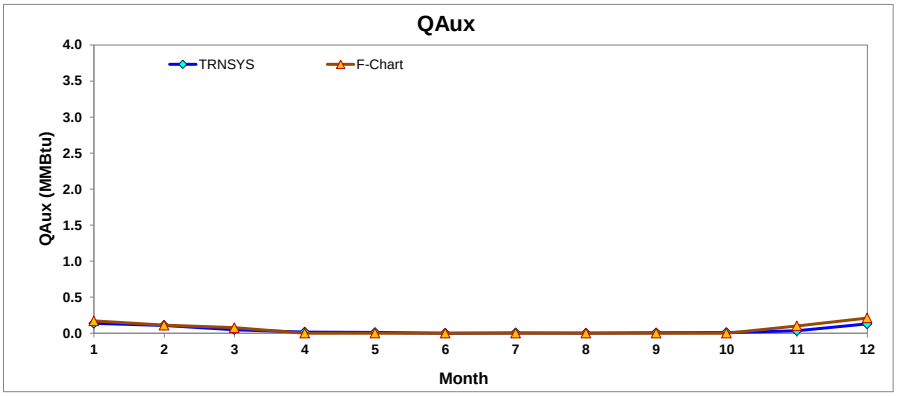


Figure 8-19Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 4 (51 gallons/day)

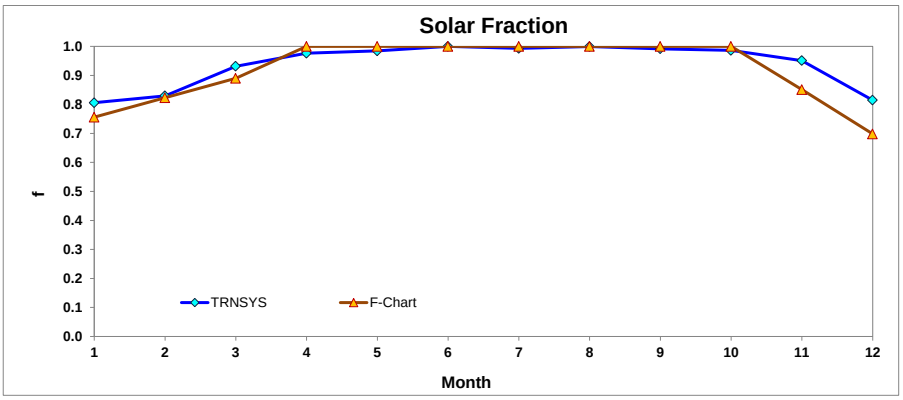


Figure 8-20Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 4 (51 gallons/day)

Table 8-2 Comparisons Data between TRNSYS and F-Chart ANALYSIS 4 (51 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	0.699	0.136	0.806	2.764	0.698	0.170	0.756	-3.1%	-0.2%	20.1%	-6.6%
Feb	2.888	0.632	0.108	0.830	2.832	0.628	0.111	0.823	-2.0%	0.6%	3.0%	-0.8%
Mar	3.789	0.696	0.048	0.932	3.639	0.691	0.076	0.890	-4.1%	0.7%	37.5%	-4.7%
Apr	3.762	0.669	0.016	0.977	3.708	0.664	0.000	1.000	-1.4%	0.8%	N/A	2.3%
May	4.101	0.687	0.010	0.985	4.046	0.682	0.000	1.000	-1.4%	0.7%	N/A	1.5%
Jun	4.176	0.661	0.000	1.000	4.145	0.656	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	4.225	0.680	0.005	0.993	4.170	0.677	0.000	1.000	-1.3%	0.5%	N/A	0.7%
Aug	4.200	0.679	0.000	1.000	4.182	0.677	0.000	1.000	-0.4%	0.3%	N/A	0.0%
Sep	4.035	0.659	0.005	0.992	3.933	0.658	0.000	1.000	-2.6%	0.1%	N/A	0.8%
Oct	4.025	0.685	0.009	0.986	3.972	0.686	0.000	1.000	-1.3%	0.1%	N/A	1.4%
Nov	3.241	0.669	0.033	0.951	3.157	0.669	0.100	0.851	-2.7%	0.0%	67.3%	-11.8%
Dec	2.575	0.696	0.129	0.815	2.503	0.695	0.210	0.698	-2.9%	0.1%	38.6%	-16.7%
Year	43.866	8.112	0.498	0.939	43.052	8.082	0.667	0.917	-1.9%	0.4%	25.3%	-2.4%

8.4 ANALYSIS 4-55 Gallons/Day

The total collector area is 80 ft^2 and daily hot water usage is 55 gallons/day with the storage tank volume 94.88 gallons.

8.4.1 F-Chart simulation

Figure 8-21 and Figure 8-22 show the input information for F-Chart. The changed settings are presented in a red box. Figure 8-23 gives the result summary of modified simulation.

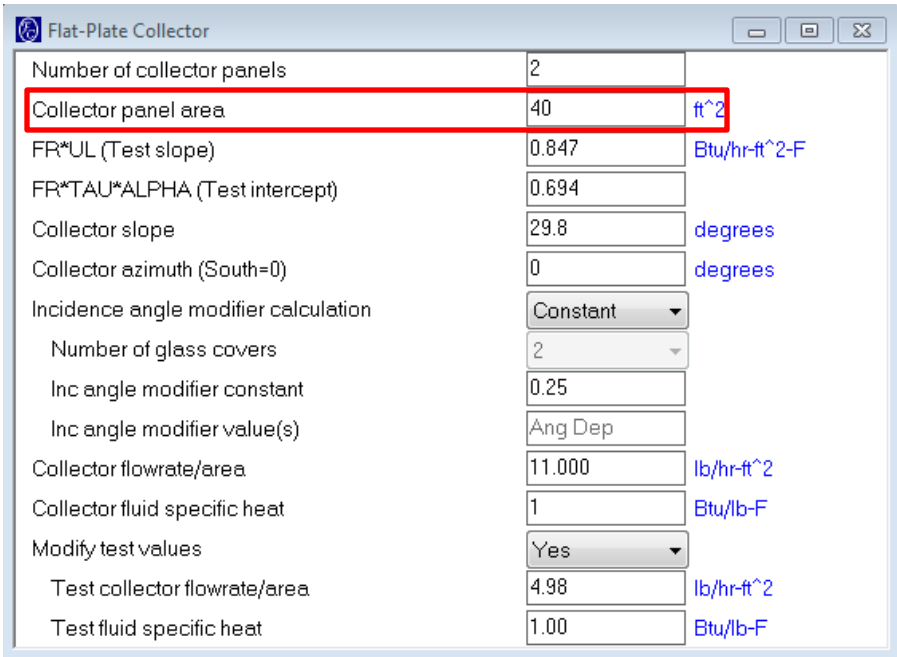


Figure 8-21 Flat-Plate Collector Input

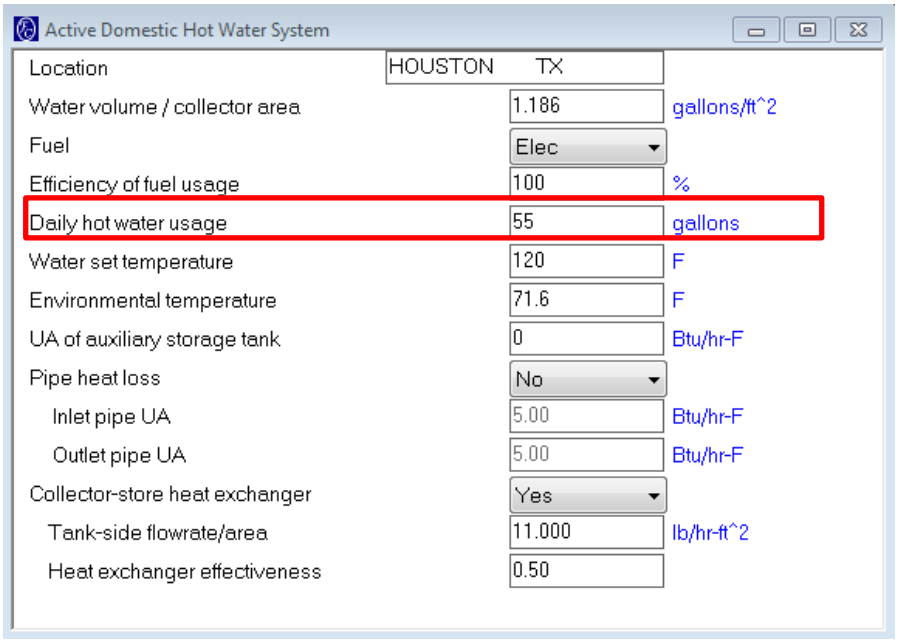
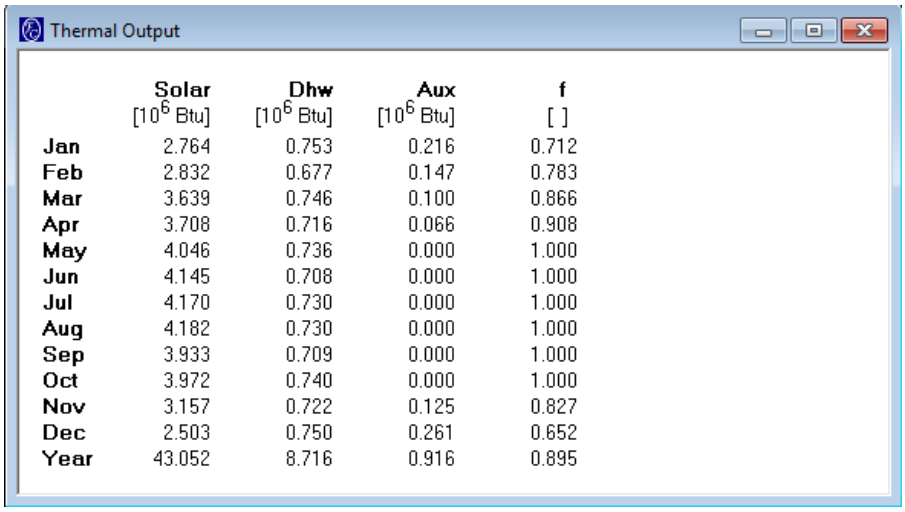


Figure 8-22 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	0.753	0.216	0.712
Feb	2.832	0.677	0.147	0.783
Mar	3.639	0.746	0.100	0.866
Apr	3.708	0.716	0.066	0.908
May	4.046	0.736	0.000	1.000
Jun	4.145	0.708	0.000	1.000
Jul	4.170	0.730	0.000	1.000
Aug	4.182	0.730	0.000	1.000
Sep	3.933	0.709	0.000	1.000
Oct	3.972	0.740	0.000	1.000
Nov	3.157	0.722	0.125	0.827
Dec	2.503	0.750	0.261	0.652
Year	43.052	8.716	0.916	0.895

Figure 8-23 F-Chart Simulation

8.4.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 8-24 , Figure 8-25 and Figure 8-26.

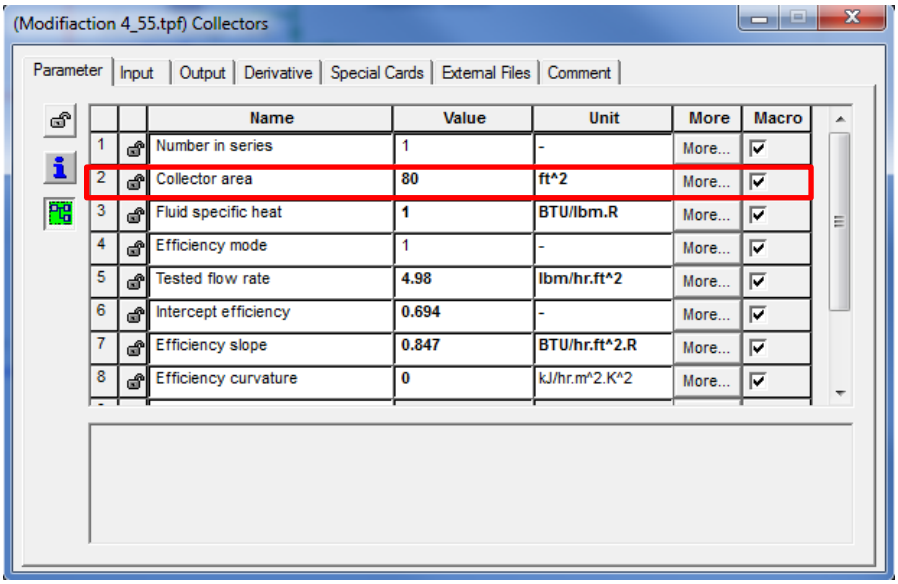


Figure 8-24 TRNSYS Component “Collectors” Settings

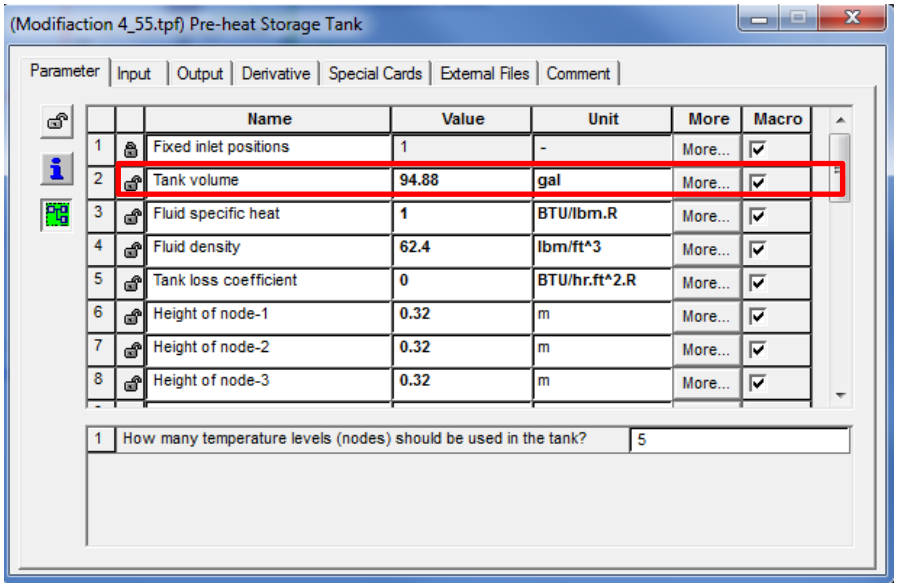


Figure 8-25 TRNSYS Component "Pre-heat Storage tank" Settings

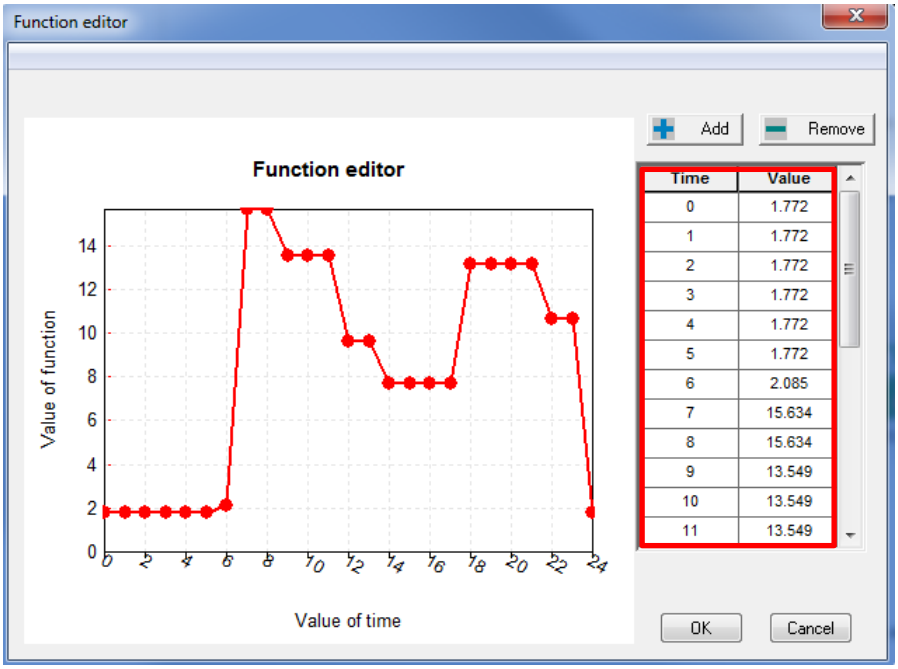


Figure 8-26 TRNSYS Component "Hot Water Demand" Settings

Figure 8-27 - Figure 8-30 present the simulation comparisons for ANALYSIS 4 (55 gallons/day) including Solar, Dhw, Aux and f factor. In Table 8-3 , Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 32.8% and -3.9 %, respectively.

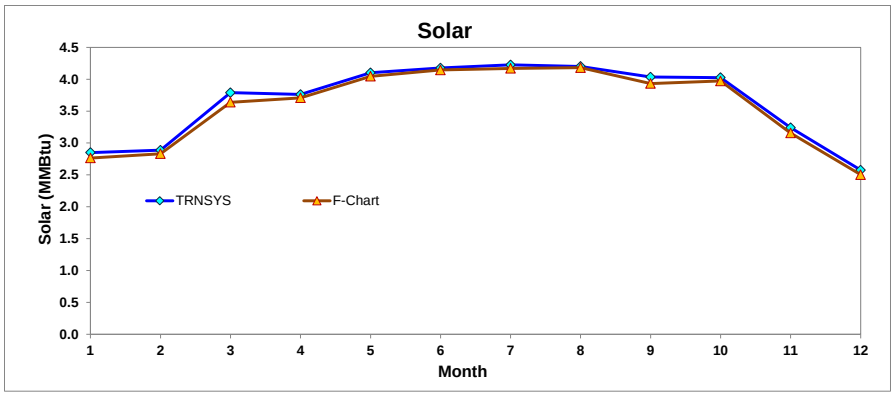


Figure 8-27 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 4 (55 gallons/day)

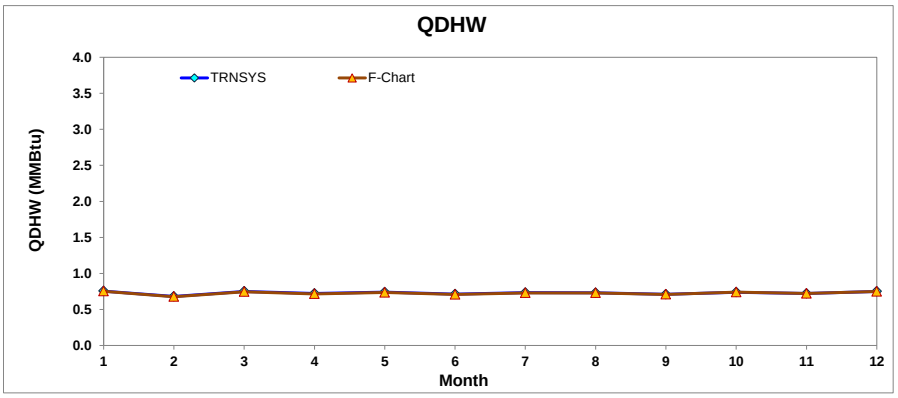


Figure 8-28Monthly Total Water Heating Demand -ANALYSIS 4 (55 gallons/day)

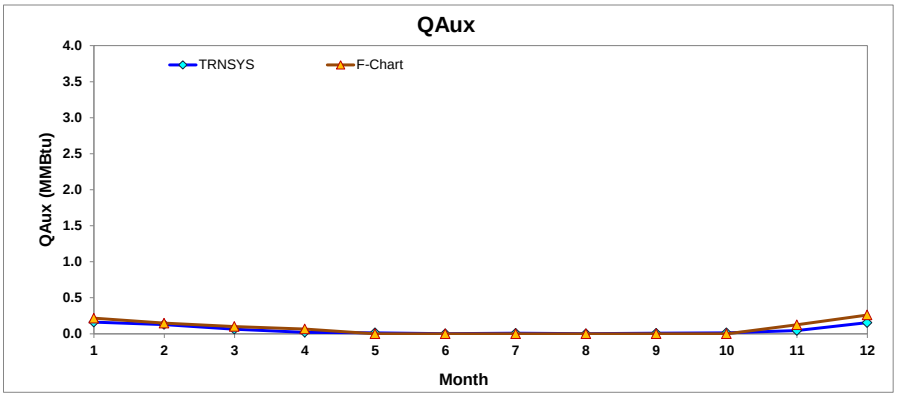


Figure 8-29Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 4 (55 gallons/day)

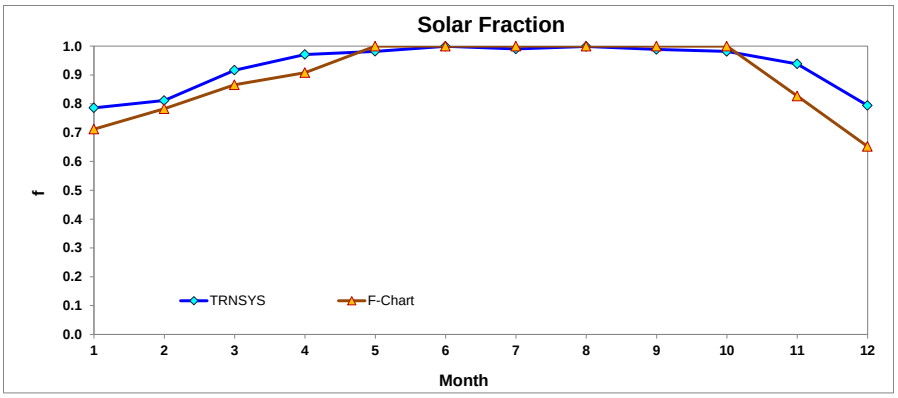


Figure 8-30Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 4 (55 gallons/day)

Table 8-3 Comparisons Data between TRNSYS and F-Chart ANALYSIS 4 (55 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	0.755	0.162	0.786	2.764	0.753	0.216	0.712	-3.1%	-0.3%	25.2%	-10.4%
Feb	2.888	0.681	0.128	0.812	2.832	0.677	0.147	0.783	-2.0%	0.6%	12.7%	-3.6%
Mar	3.789	0.751	0.063	0.917	3.639	0.746	0.100	0.866	-4.1%	0.6%	37.4%	-5.8%
Apr	3.762	0.722	0.021	0.971	3.708	0.716	0.066	0.908	-1.4%	0.8%	68.5%	-7.0%
May	4.101	0.741	0.013	0.982	4.046	0.736	0.000	1.000	-1.4%	0.6%	N/A	1.8%
Jun	4.176	0.712	0.000	1.000	4.145	0.708	0.000	1.000	-0.7%	0.6%	N/A	0.0%
Jul	4.225	0.734	0.007	0.990	4.170	0.730	0.000	1.000	-1.3%	0.5%	N/A	1.0%
Aug	4.200	0.732	0.001	0.999	4.182	0.730	0.000	1.000	-0.4%	0.2%	N/A	0.1%
Sep	4.035	0.711	0.008	0.989	3.933	0.709	0.000	1.000	-2.6%	0.2%	N/A	1.1%
Oct	4.025	0.739	0.014	0.982	3.972	0.740	0.000	1.000	-1.3%	0.1%	N/A	1.8%
Nov	3.241	0.722	0.044	0.939	3.157	0.722	0.125	0.827	-2.7%	0.1%	N/A	-13.5%
Dec	2.575	0.751	0.154	0.794	2.503	0.750	0.261	0.652	-2.9%	0.1%	N/A	-21.8%
Year	43.866	8.750	0.615	0.930	43.052	8.716	0.916	0.895	-1.9%	0.4%	32.8%	-3.9%

8.5 Analysis 4-85 Gallons/Day

The total collector area is 80 ft^2 and daily hot water usage is 85 gallons/day with the storage tank volume 94.88 gallons.

8.5.1 F-Chart simulation

Figure 8-31 and Figure 8-32 show the input information for F-Chart. The changed settings are presented in a red box. Figure 8-33 gives the result summary of modified simulation.

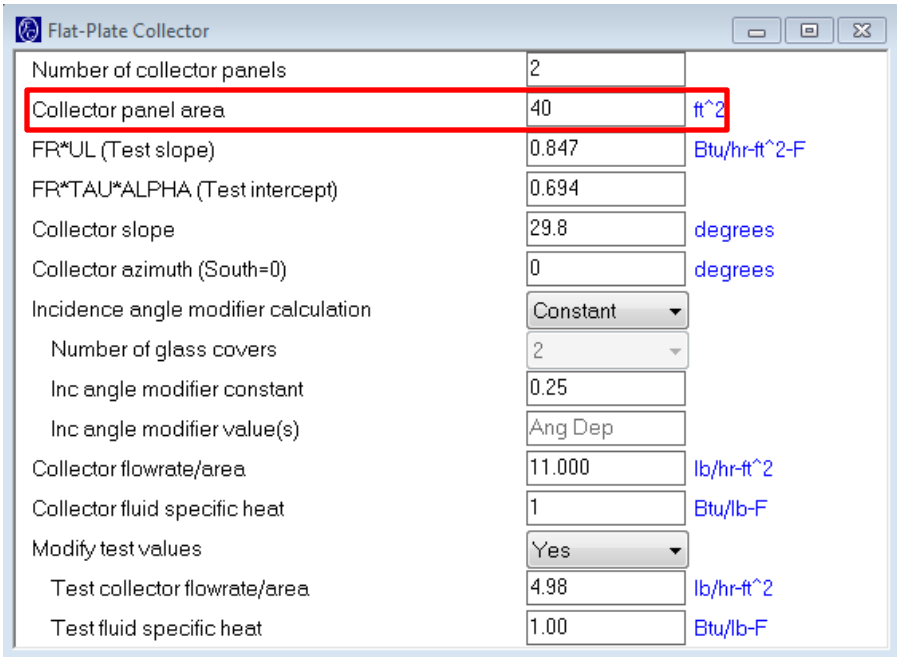


Figure 8-31 Flat-Plate Collector Input

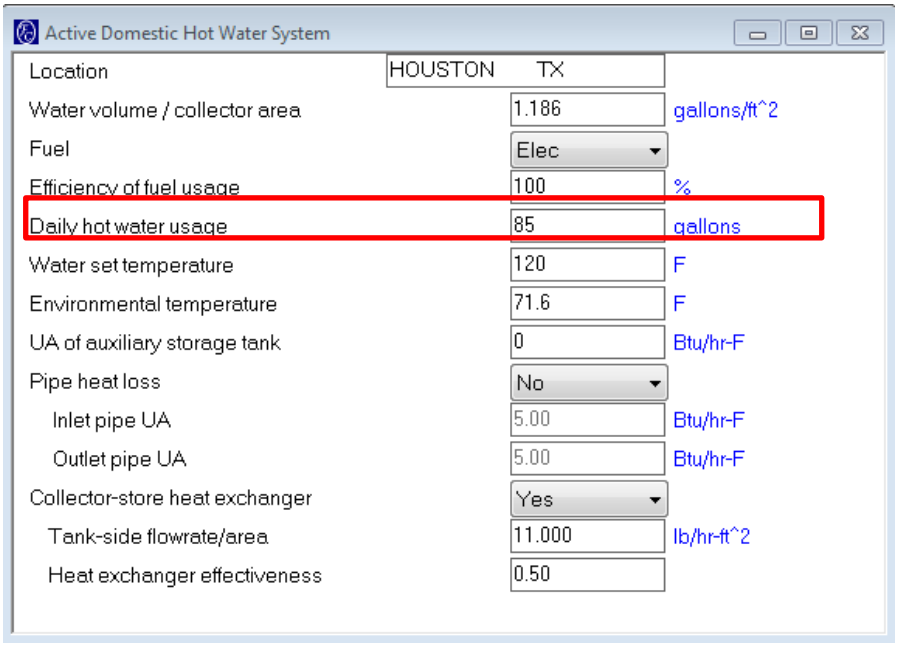
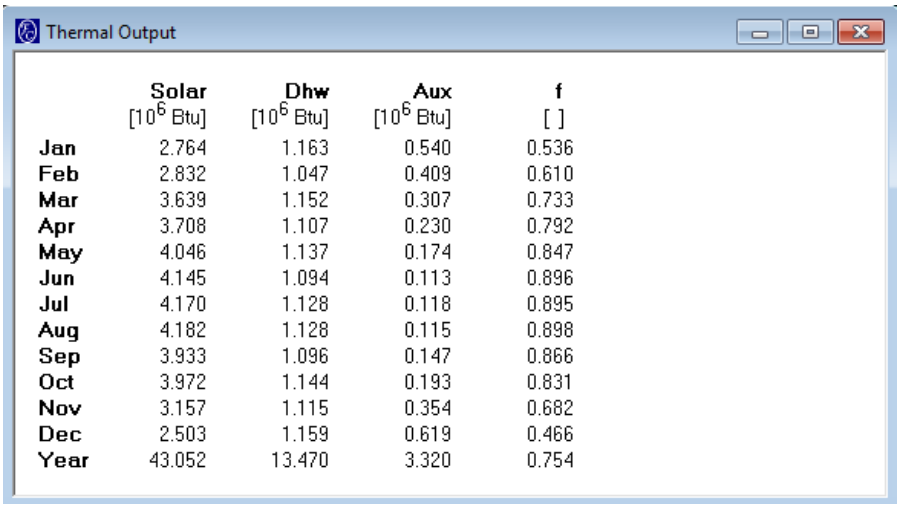


Figure 8-32 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	1.163	0.540	0.536
Feb	2.832	1.047	0.409	0.610
Mar	3.639	1.152	0.307	0.733
Apr	3.708	1.107	0.230	0.792
May	4.046	1.137	0.174	0.847
Jun	4.145	1.094	0.113	0.896
Jul	4.170	1.128	0.118	0.895
Aug	4.182	1.128	0.115	0.898
Sep	3.933	1.096	0.147	0.866
Oct	3.972	1.144	0.193	0.831
Nov	3.157	1.115	0.354	0.682
Dec	2.503	1.159	0.619	0.466
Year	43.052	13.470	3.320	0.754

Figure 8-33 F-Chart Simulation

8.5.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 8-34 , Figure 8-35 and Figure 8-36.

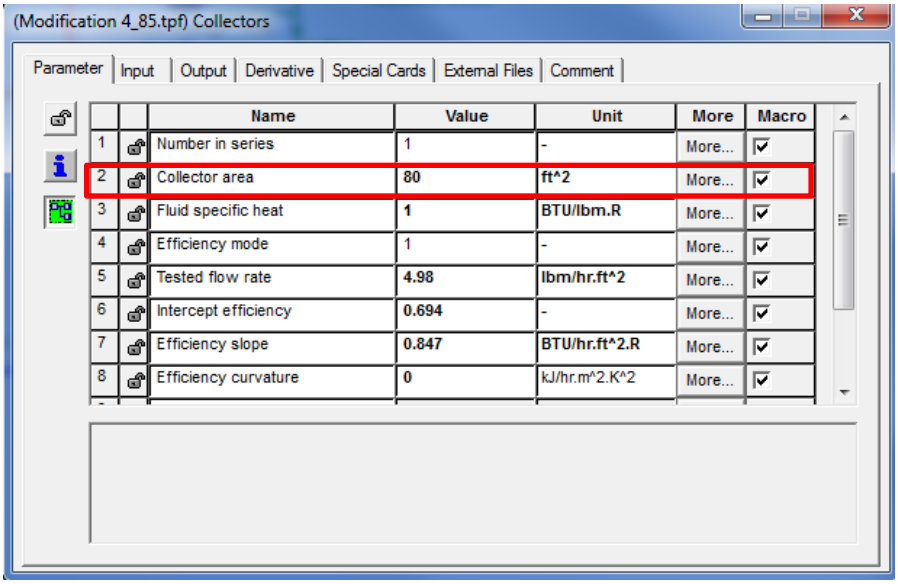


Figure 8-34 TRNSYS Component “Collectors” Settings

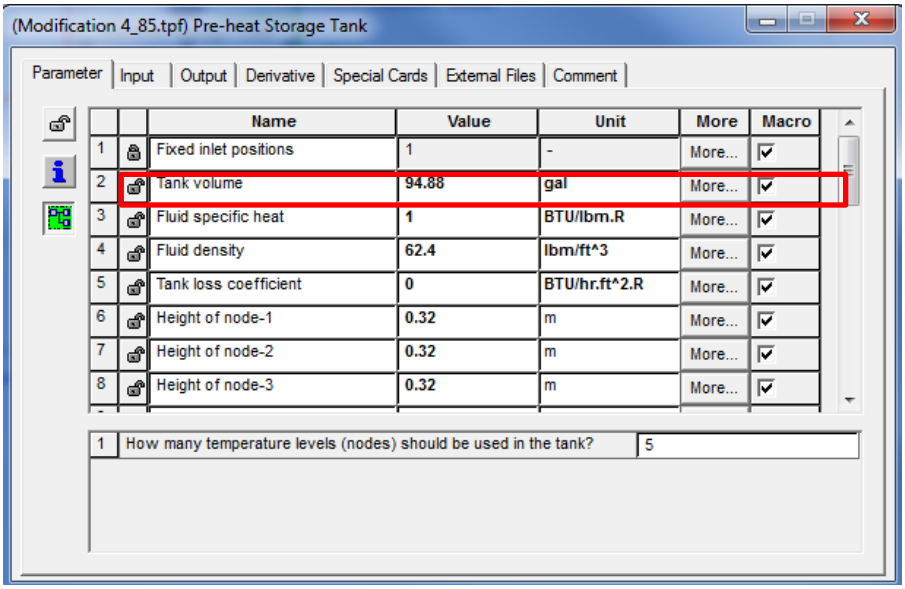


Figure 8-35 TRNSYS Component "Pre-heat Storage tank" Settings

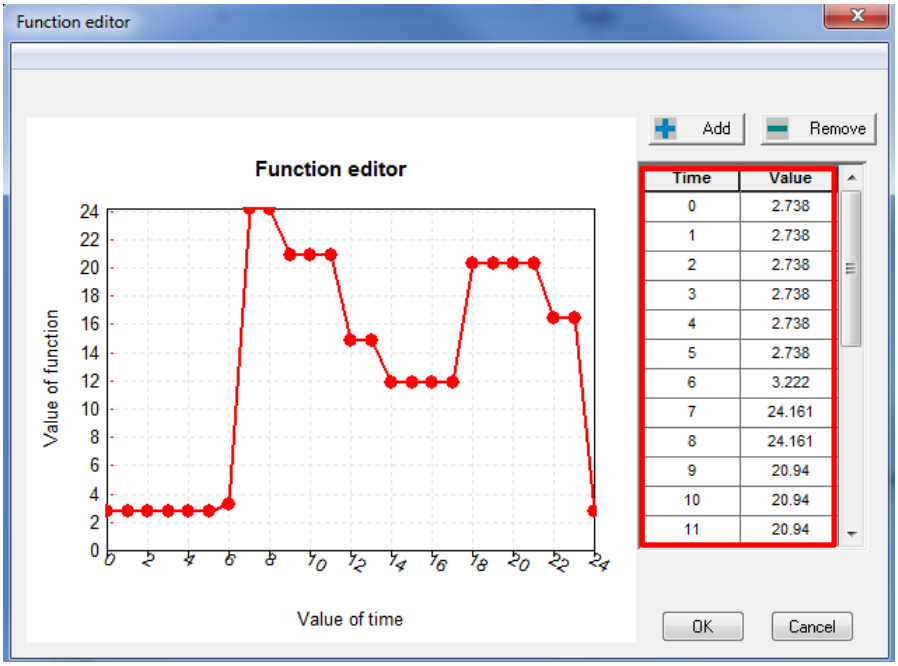


Figure 8-36 TRNSYS Component "Hot Water Demand" Settings

Figure 8-37 - Figure 8-40 present the simulation comparisons for ANALYSIS 4 (85 gallons/day) including Solar, Dhw, Aux and f factor. In Table 8-4, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 41.9% and -13.7 %, respectively.

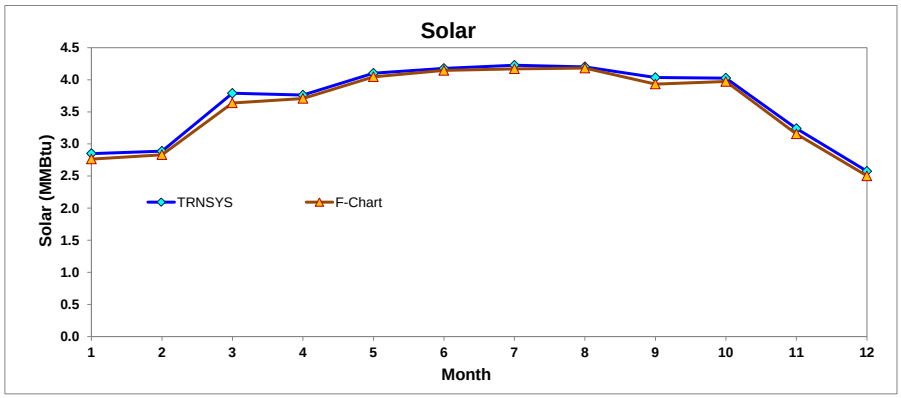


Figure 8-37 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 4 (85 gallons/day)

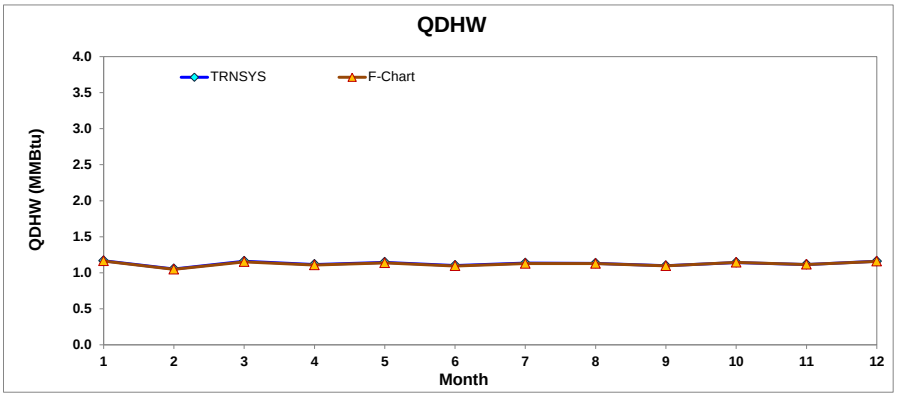


Figure 8-38Monthly Total Water Heating Demand -ANALYSIS 4 (85 gallons/day)

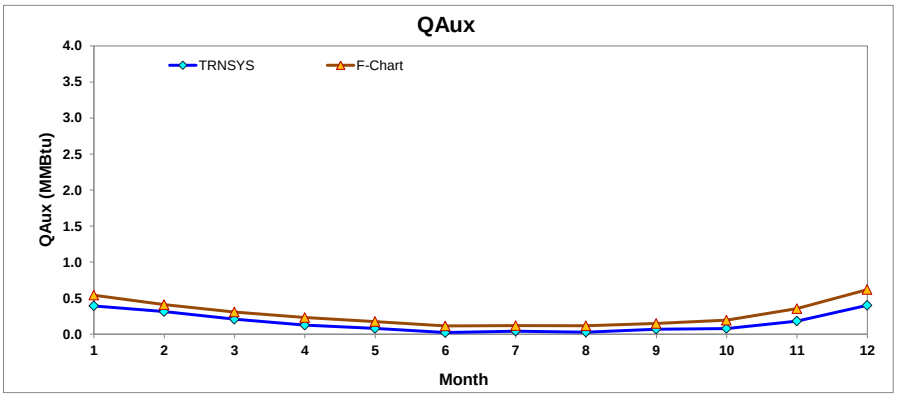


Figure 8-39Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 4 (85 gallons/day)

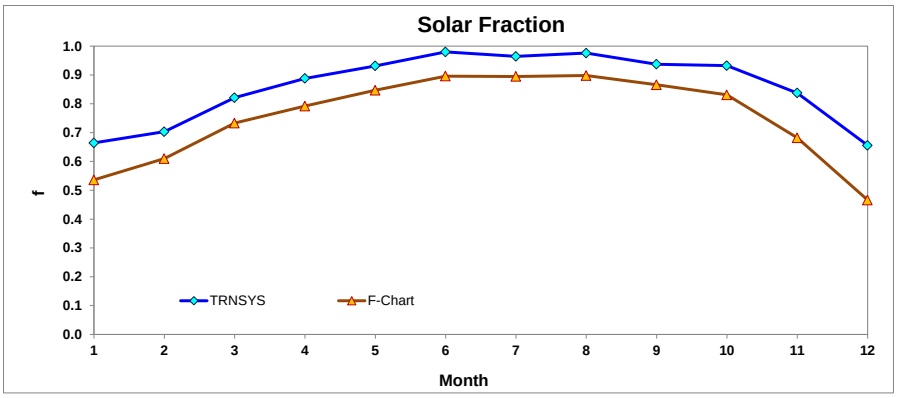


Figure 8-40Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 4 (85 gallons/day)

Table 8-4 Comparisons Data between TRNSYS and F-Chart ANALYSIS 4 (85 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	1.166	0.391	0.664	2.764	1.163	0.540	0.536	-3.1%	-0.3%	27.5%	-24.0%
Feb	2.888	1.053	0.312	0.703	2.832	1.047	0.409	0.610	-2.0%	0.5%	23.6%	-15.3%
Mar	3.789	1.160	0.207	0.821	3.639	1.152	0.307	0.733	-4.1%	0.7%	32.5%	-12.1%
Apr	3.762	1.115	0.125	0.888	3.708	1.107	0.230	0.792	-1.4%	0.7%	45.7%	-12.1%
May	4.101	1.145	0.078	0.932	4.046	1.137	0.174	0.847	-1.4%	0.7%	55.0%	-10.0%
Jun	4.176	1.101	0.022	0.980	4.145	1.094	0.113	0.896	-0.7%	0.7%	80.6%	-9.4%
Jul	4.225	1.134	0.040	0.964	4.170	1.128	0.118	0.895	-1.3%	0.5%	65.8%	-7.8%
Aug	4.200	1.131	0.027	0.976	4.182	1.128	0.115	0.898	-0.4%	0.3%	76.5%	-8.7%
Sep	4.035	1.098	0.069	0.937	3.933	1.096	0.147	0.866	-2.6%	0.2%	53.2%	-8.2%
Oct	4.025	1.142	0.077	0.932	3.972	1.144	0.193	0.831	-1.3%	0.1%	60.0%	-12.2%
Nov	3.241	1.115	0.181	0.838	3.157	1.115	0.354	0.682	-2.7%	0.0%	48.9%	-22.8%
Dec	2.575	1.160	0.399	0.656	2.503	1.159	0.619	0.466	-2.9%	0.1%	35.5%	-40.7%
Year	43.866	13.522	1.930	0.857	43.052	13.470	3.320	0.754	-1.9%	0.4%	41.9%	-13.7%

8.6 ANALYSIS 4-106 Gallons/Day

The total collector area is 80 ft^2 and daily hot water usage is 106 gallons/day with the storage tank volume 94.88 gallons.

8.6.1 F-Chart simulation

Figure 8-41 and Figure 8-42 show the input information for F-Chart. The changed settings are presented in a red box. Figure 8-43 gives the result summary of modified simulation.

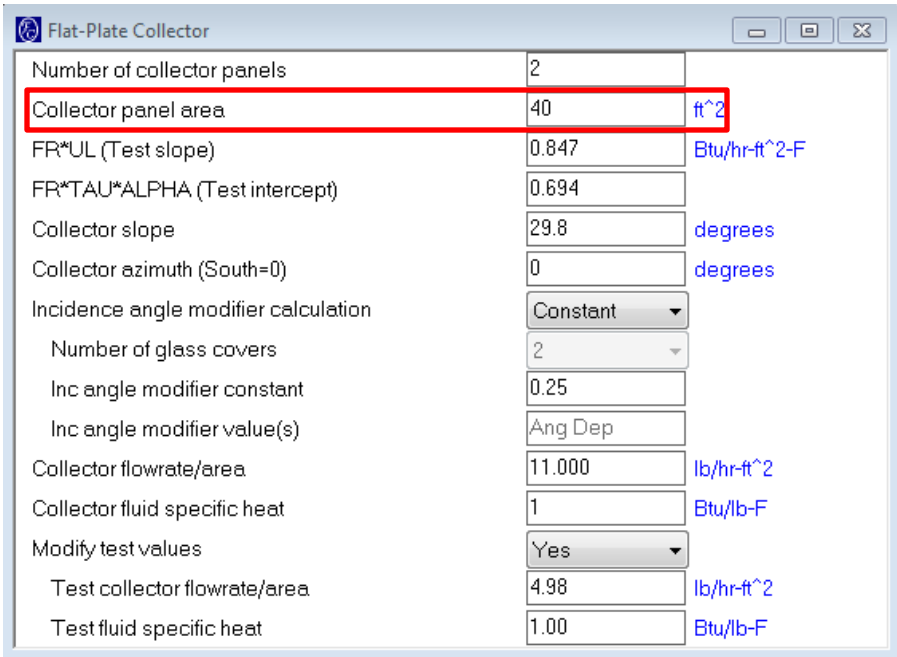


Figure 8-41 Flat-Plate Collector Input

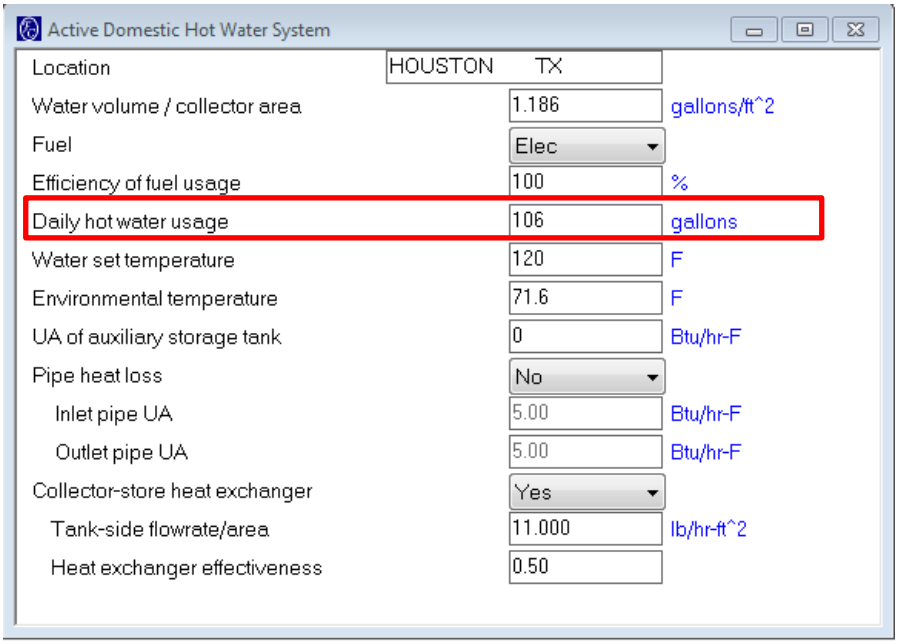
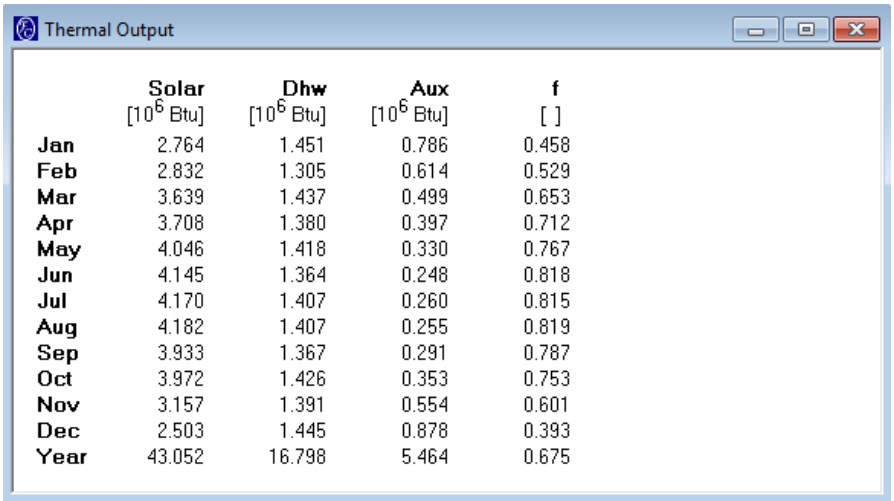


Figure 8-42 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	1.451	0.786	0.458
Feb	2.832	1.305	0.614	0.529
Mar	3.639	1.437	0.499	0.653
Apr	3.708	1.380	0.397	0.712
May	4.046	1.418	0.330	0.767
Jun	4.145	1.364	0.248	0.818
Jul	4.170	1.407	0.260	0.815
Aug	4.182	1.407	0.255	0.819
Sep	3.933	1.367	0.291	0.787
Oct	3.972	1.426	0.353	0.753
Nov	3.157	1.391	0.554	0.601
Dec	2.503	1.445	0.878	0.393
Year	43.052	16.798	5.464	0.675

Figure 8-43 F-Chart Simulation

8.6.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 8-44 , Figure 8-45 and Figure 8-46.

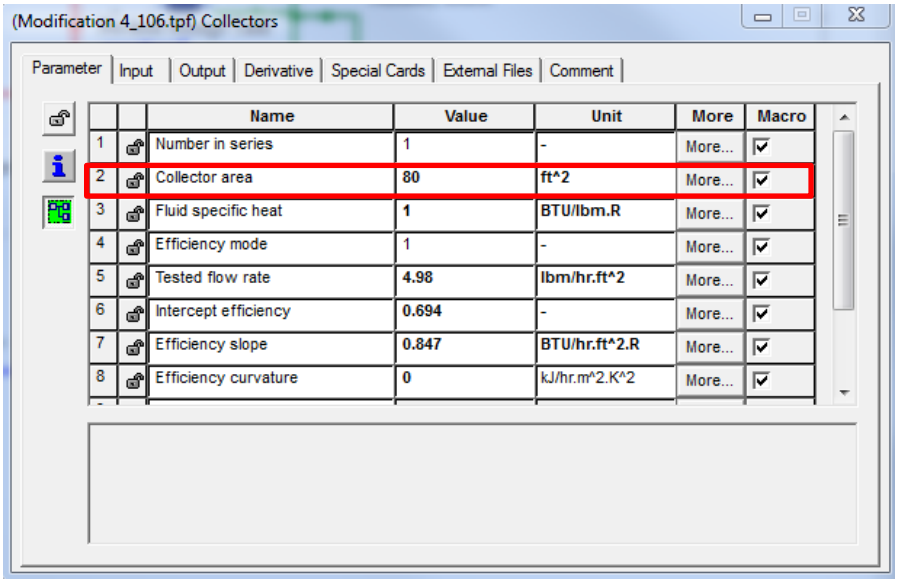


Figure 8-44 TRNSYS Component “Collectors” Settings

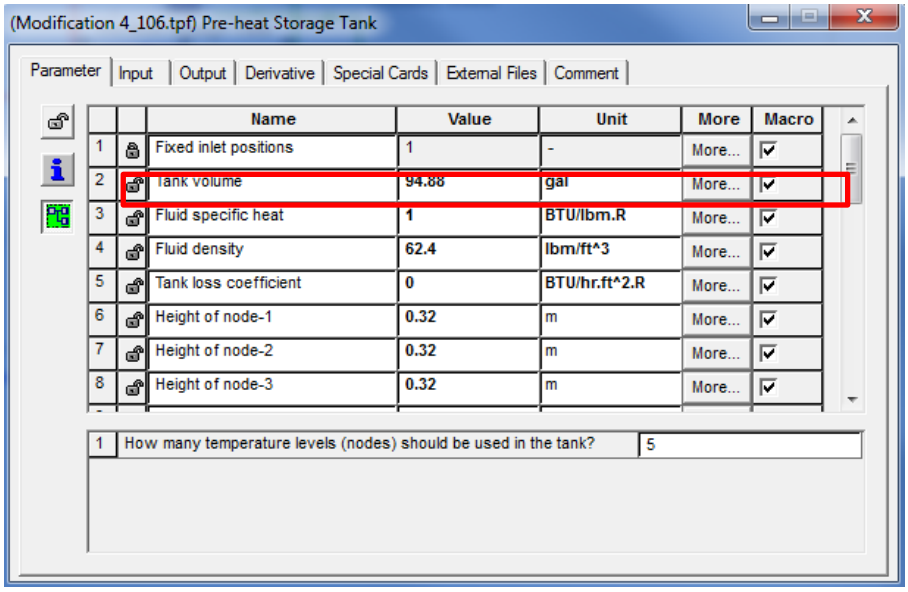


Figure 8-45 TRNSYS Component "Pre-heat Storage tank" Settings

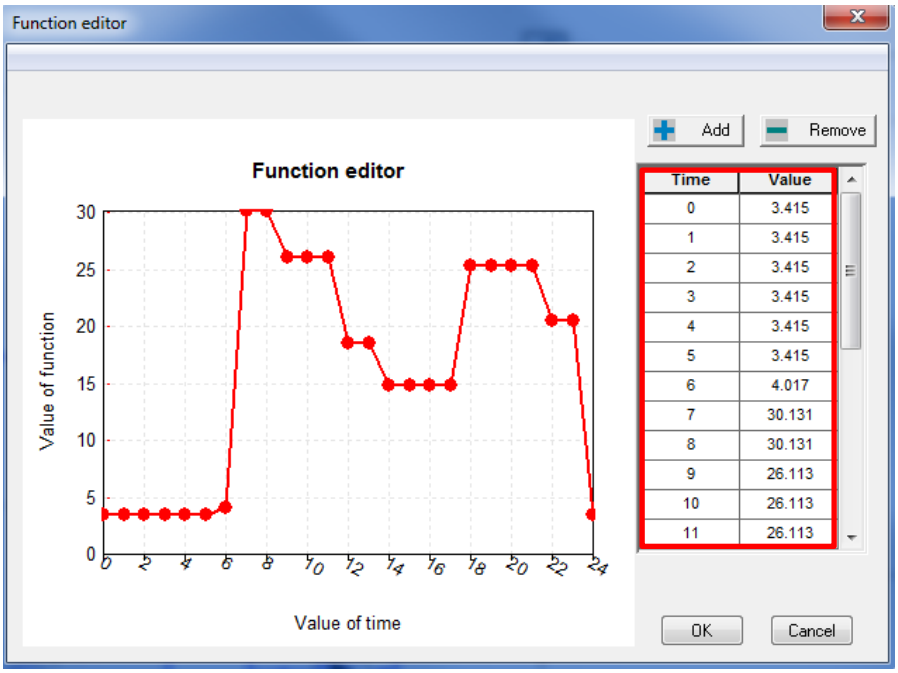


Figure 8-46 TRNSYS Component "Hot Water Demand" Settings

Figure 8-47 - Figure 8-50 present the simulation comparisons for ANALYSIS 4 (106 gallons/day) including Solar, Dhw, Aux and f factor. In Table 8-5 , Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 37.5% and -18.2%, respectively.

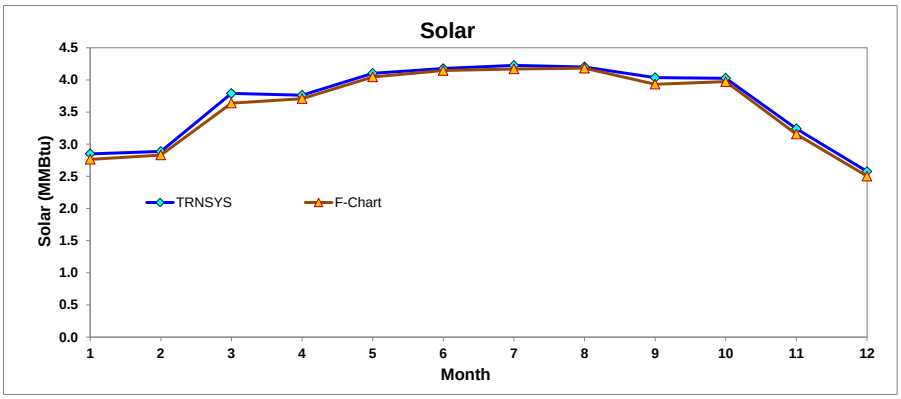


Figure 8-47 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 4 (106 gallons/day)

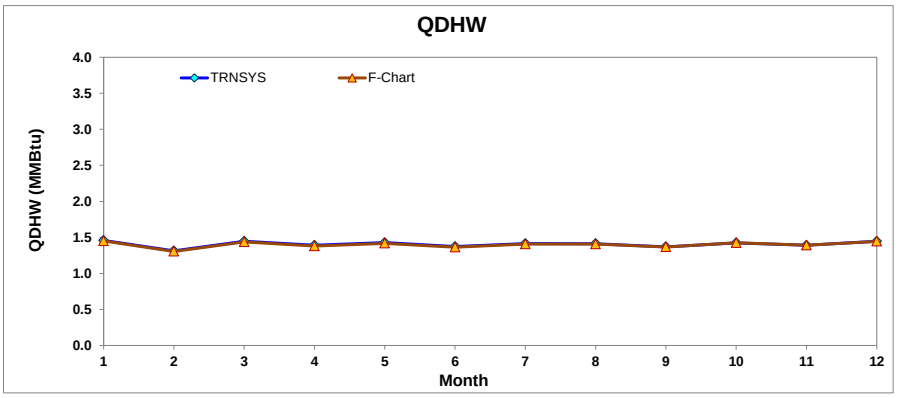


Figure 8-48Monthly Total Water Heating Demand -ANALYSIS 4 (106 gallons/day)

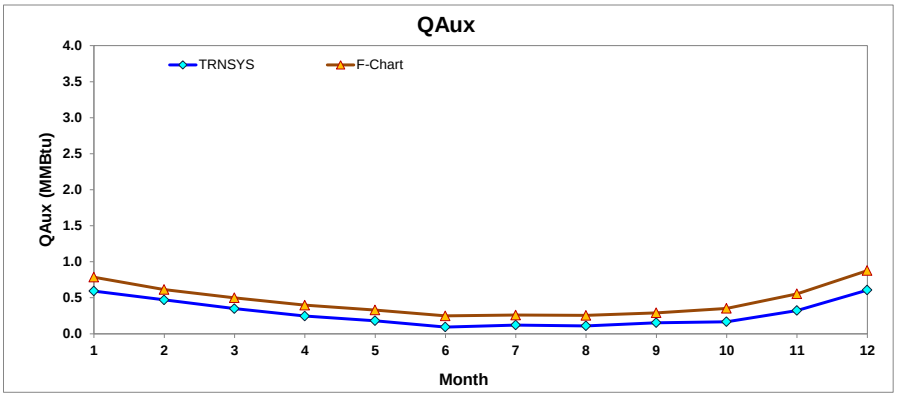


Figure 8-49Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 4 (106 gallons/day)

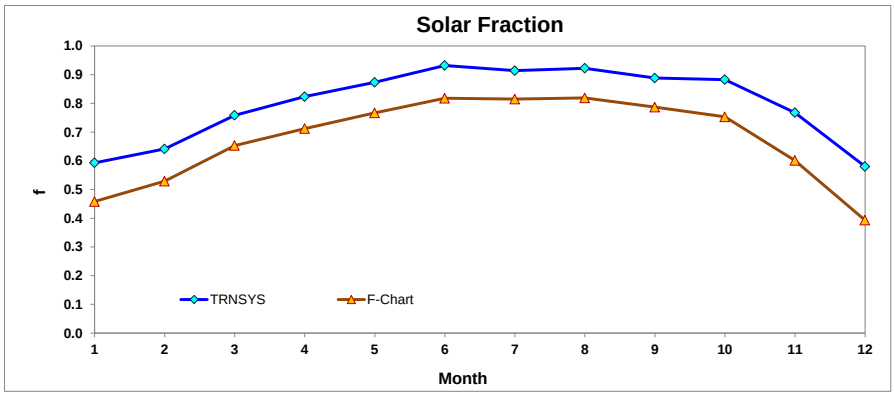


Figure 8-50Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 4 (106 gallons/day)

Table 8-5 Comparisons Data between TRNSYS and F-Chart ANALYSIS 4 (106 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	1.457	0.593	0.593	2.764	1.451	0.786	0.458	-3.1%	-0.4%	24.5%	-29.5%
Feb	2.888	1.313	0.471	0.641	2.832	1.305	0.614	0.529	-2.0%	0.6%	23.3%	-21.3%
Mar	3.789	1.447	0.349	0.759	3.639	1.437	0.499	0.653	-4.1%	0.7%	30.0%	-16.2%
Apr	3.762	1.391	0.245	0.824	3.708	1.380	0.397	0.712	-1.4%	0.8%	38.2%	-15.7%
May	4.101	1.428	0.181	0.873	4.046	1.418	0.330	0.767	-1.4%	0.7%	45.2%	-13.9%
Jun	4.176	1.373	0.093	0.932	4.145	1.364	0.248	0.818	-0.7%	0.7%	62.5%	-14.0%
Jul	4.225	1.414	0.122	0.914	4.170	1.407	0.260	0.815	-1.3%	0.5%	53.2%	-12.1%
Aug	4.200	1.413	0.109	0.923	4.182	1.407	0.255	0.819	-0.4%	0.4%	57.1%	-12.6%
Sep	4.035	1.369	0.153	0.888	3.933	1.367	0.291	0.787	-2.6%	0.2%	47.5%	-12.9%
Oct	4.025	1.425	0.167	0.883	3.972	1.426	0.353	0.753	-1.3%	0.1%	52.7%	-17.3%
Nov	3.241	1.391	0.323	0.768	3.157	1.391	0.554	0.601	-2.7%	0.0%	41.7%	-27.7%
Dec	2.575	1.447	0.607	0.580	2.503	1.445	0.878	0.393	-2.9%	0.1%	30.8%	-47.6%
Year	43.866	16.867	3.413	0.798	43.052	16.798	5.464	0.675	-1.9%	0.4%	37.5%	-18.2%

8.7 ANALYSIS 4-107 Gallons/Day

The total collector area is 80 ft^2 and daily hot water usage is 107 gallons/day with the storage tank volume 94.88 gallons.

8.7.1 F-Chart simulation

Figure 8-51 and Figure 8-52 show the input information for F-Chart. The changed settings are presented in a red box. Figure 8-53 gives the result summary of modified simulation.

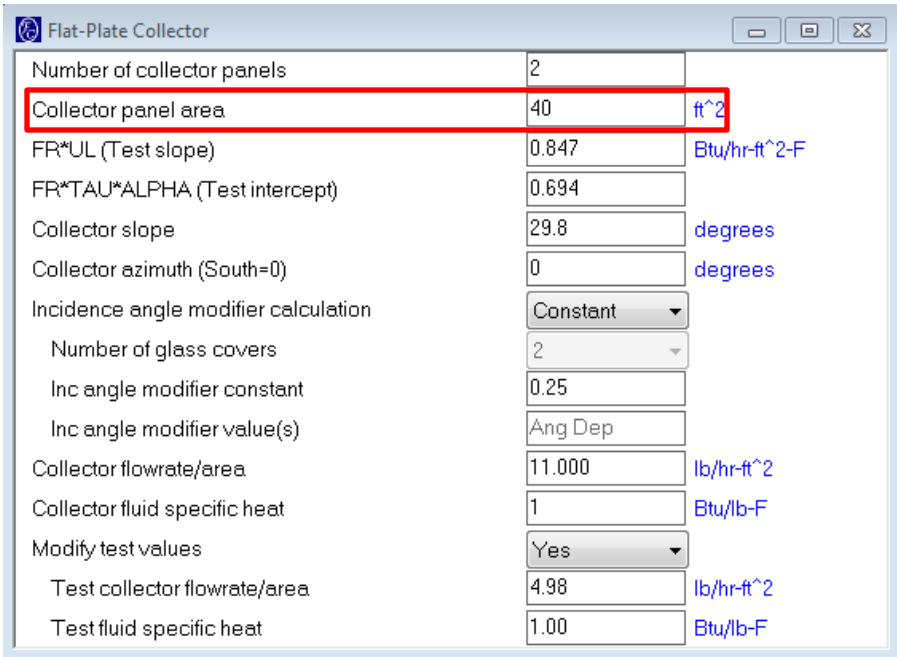


Figure 8-51 Flat-Plate Collector Input

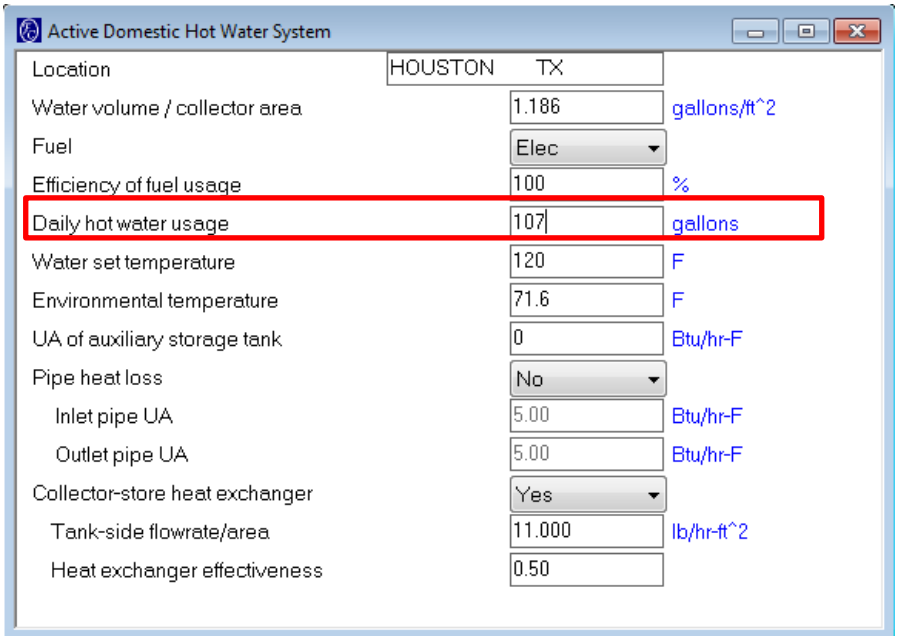
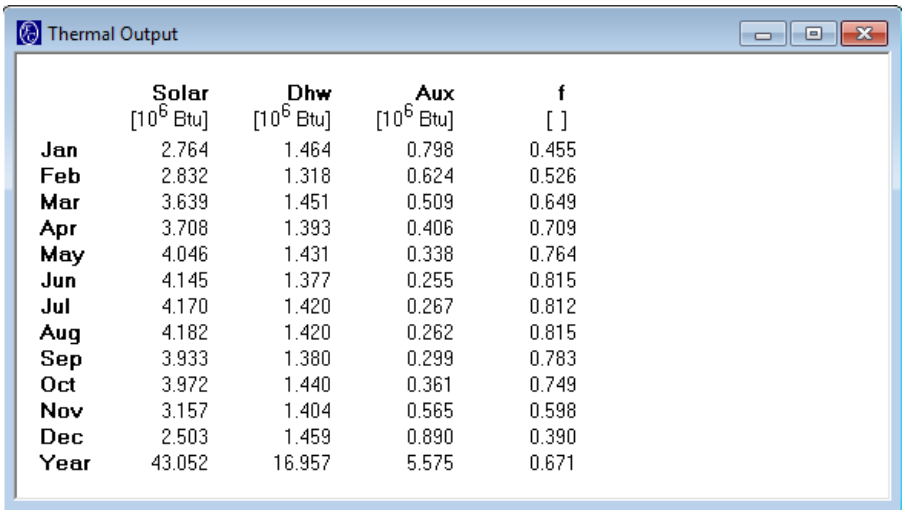


Figure 8-52 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	1.464	0.798	0.455
Feb	2.832	1.318	0.624	0.526
Mar	3.639	1.451	0.509	0.649
Apr	3.708	1.393	0.406	0.709
May	4.046	1.431	0.338	0.764
Jun	4.145	1.377	0.255	0.815
Jul	4.170	1.420	0.267	0.812
Aug	4.182	1.420	0.262	0.815
Sep	3.933	1.380	0.299	0.783
Oct	3.972	1.440	0.361	0.749
Nov	3.157	1.404	0.565	0.598
Dec	2.503	1.459	0.890	0.390
Year	43.052	16.957	5.575	0.671

Figure 8-53 F-Chart Simulation

8.7.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 8-54, Figure 8-55 and Figure 8-56.

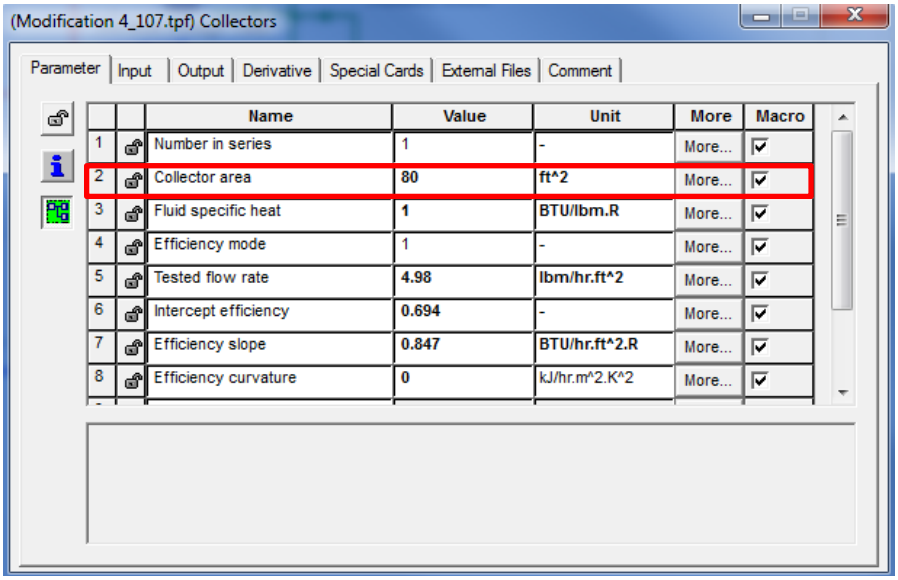


Figure 8-54 TRNSYS Component “Collectors” Settings

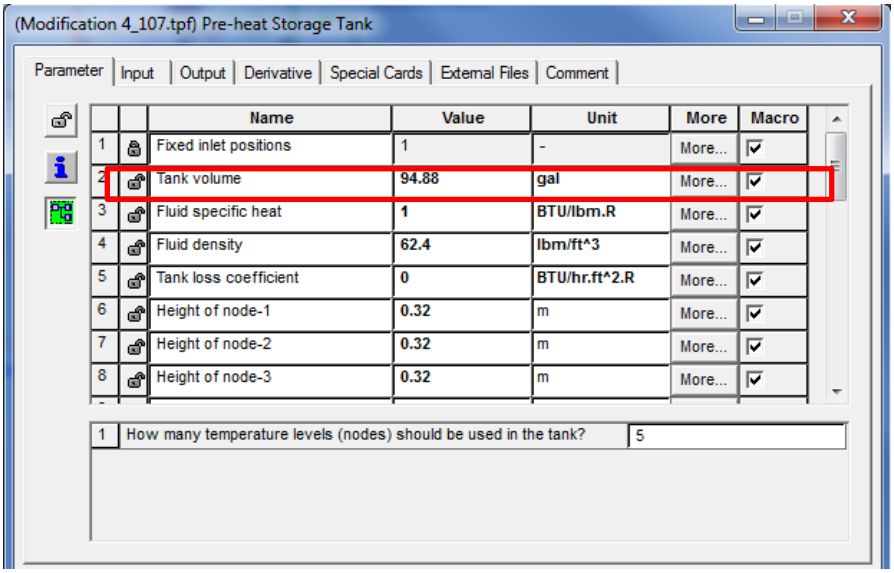


Figure 8-55 TRNSYS Component "Pre-heat Storage tank" Settings

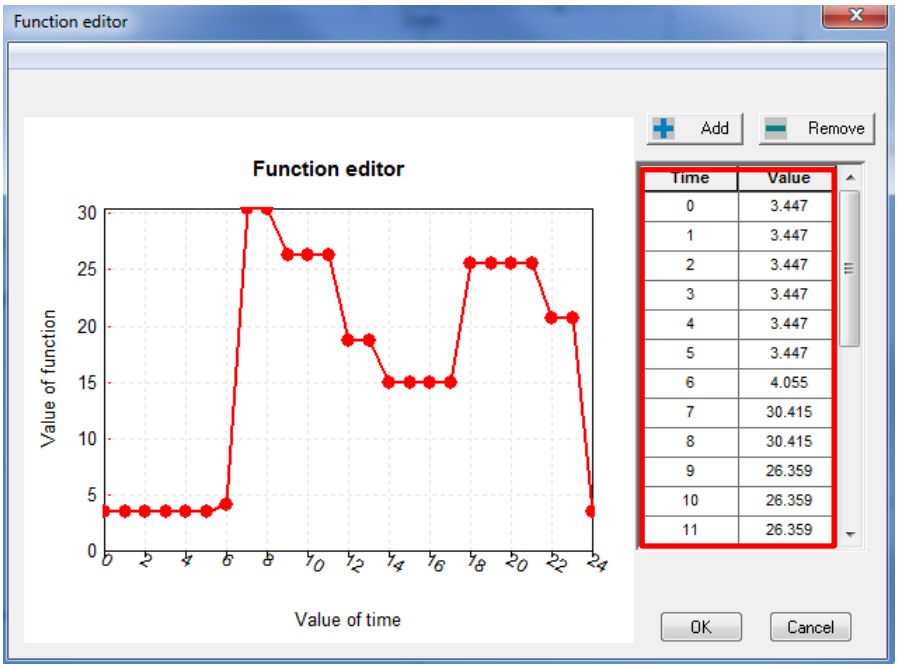


Figure 8-56 TRNSYS Component "Hot Water Demand" Settings

Figure 8-57 - Figure 8-60 present the simulation comparisons for ANALYSIS 4 (107 gallons/day) including Solar, Dhw, Aux and f factor. In Table 8-6, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 37.2% and -18.4%, respectively.

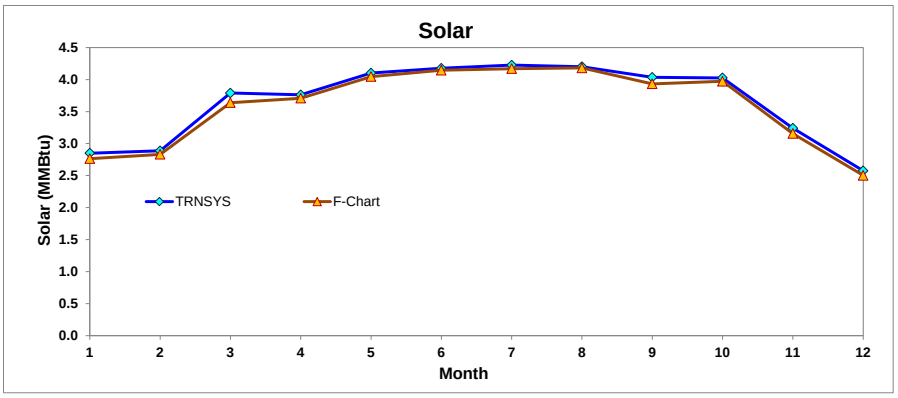


Figure 8-57 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 4 (107 gallons/day)

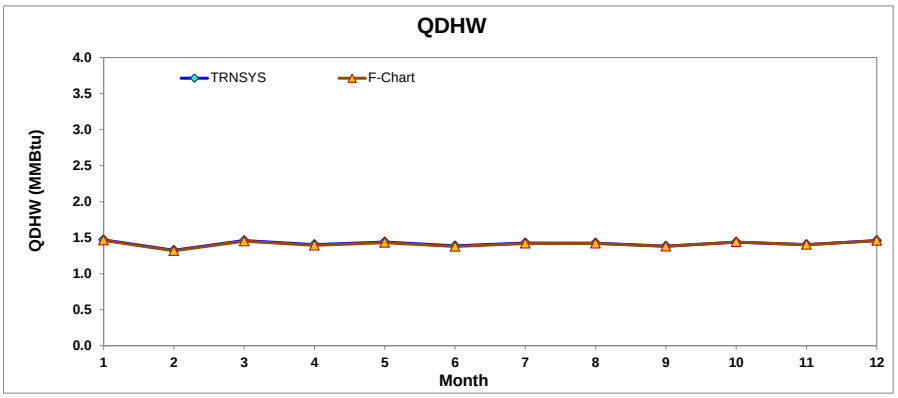


Figure 8-58Monthly Total Water Heating Demand -ANALYSIS 4 (107 gallons/day)

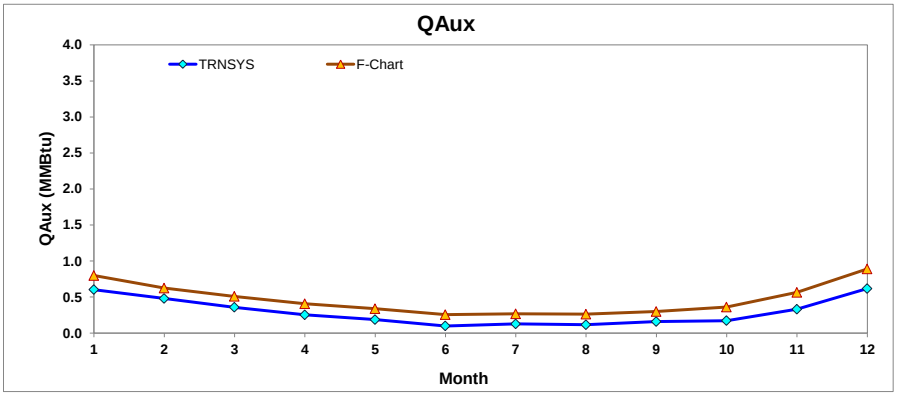


Figure 8-59Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 4 (107 gallons/day)

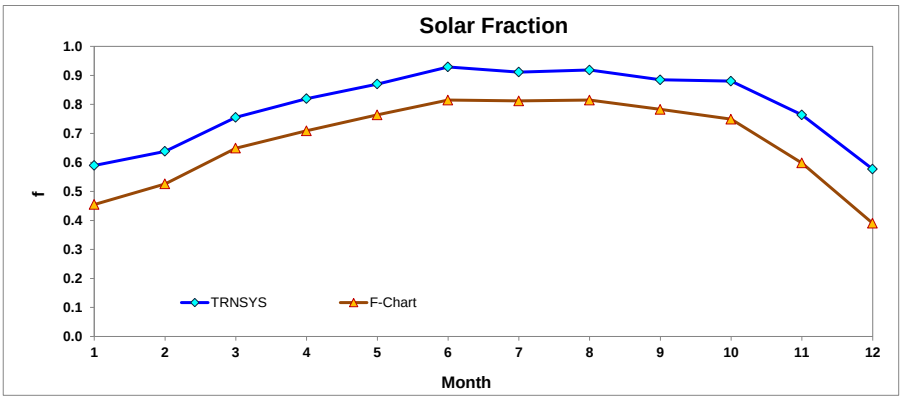


Figure 8-60Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 4 (107 gallons/day)

Table 8-6 Comparisons Data between TRNSYS and F-Chart ANALYSIS 4 (107 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	1.469	0.603	0.590	2.764	1.464	0.798	0.455	-3.1%	-0.3%	24.4%	-29.6%
Feb	2.888	1.325	0.479	0.638	2.832	1.318	0.624	0.526	-2.0%	0.6%	23.2%	-21.3%
Mar	3.789	1.460	0.357	0.756	3.639	1.451	0.509	0.649	-4.1%	0.6%	29.9%	-16.4%
Apr	3.762	1.404	0.253	0.820	3.708	1.393	0.406	0.709	-1.4%	0.8%	37.7%	-15.6%
May	4.101	1.441	0.187	0.870	4.046	1.431	0.338	0.764	-1.4%	0.7%	44.8%	-13.9%
Jun	4.176	1.386	0.098	0.929	4.145	1.377	0.255	0.815	-0.7%	0.7%	61.6%	-14.0%
Jul	4.225	1.427	0.126	0.911	4.170	1.420	0.267	0.812	-1.3%	0.5%	52.7%	-12.2%
Aug	4.200	1.425	0.116	0.919	4.182	1.420	0.262	0.815	-0.4%	0.4%	55.9%	-12.7%
Sep	4.035	1.382	0.159	0.885	3.933	1.380	0.299	0.783	-2.6%	0.2%	46.8%	-13.0%
Oct	4.025	1.438	0.172	0.880	3.972	1.440	0.361	0.749	-1.3%	0.1%	52.3%	-17.5%
Nov	3.241	1.404	0.331	0.764	3.157	1.404	0.565	0.598	-2.7%	0.0%	41.3%	-27.8%
Dec	2.575	1.460	0.618	0.577	2.503	1.459	0.890	0.390	-2.9%	0.1%	30.6%	-48.0%
Year	43.866	17.023	3.499	0.794	43.052	16.957	5.575	0.671	-1.9%	0.4%	37.2%	-18.4%

8.8 Analysis 4-115 Gallons/Day

The total collector area is 80 ft^2 and daily hot water usage is 115 gallons/day with the storage tank volume 94.88 gallons.

8.8.1 F-Chart simulation

Figure 8-61 and Figure 8-62 show the input information for F-Chart. The changed settings are presented in a red box. Figure 8-63 gives the result summary of modified simulation.

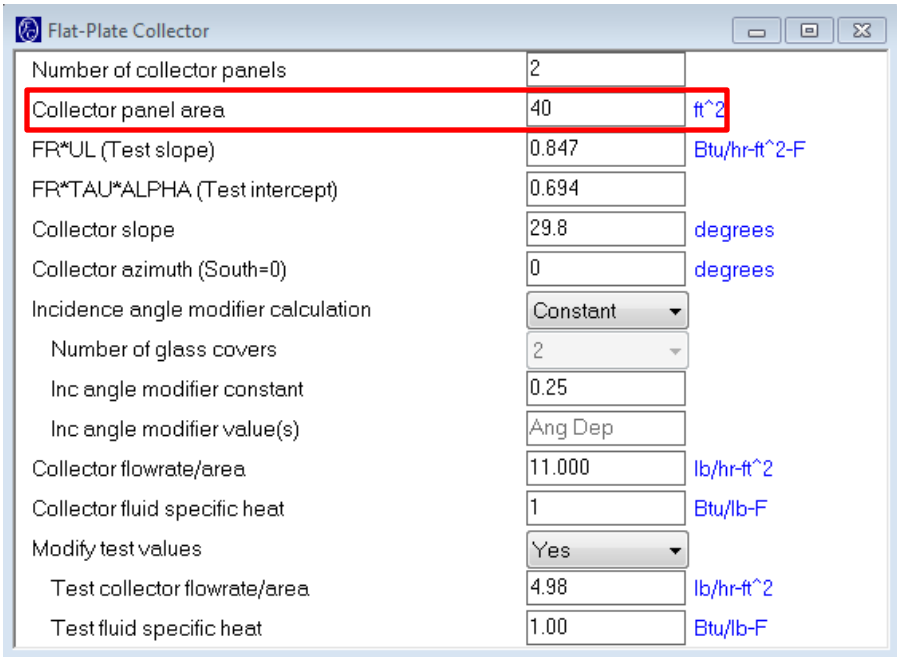


Figure 8-61 Flat-Plate Collector Input

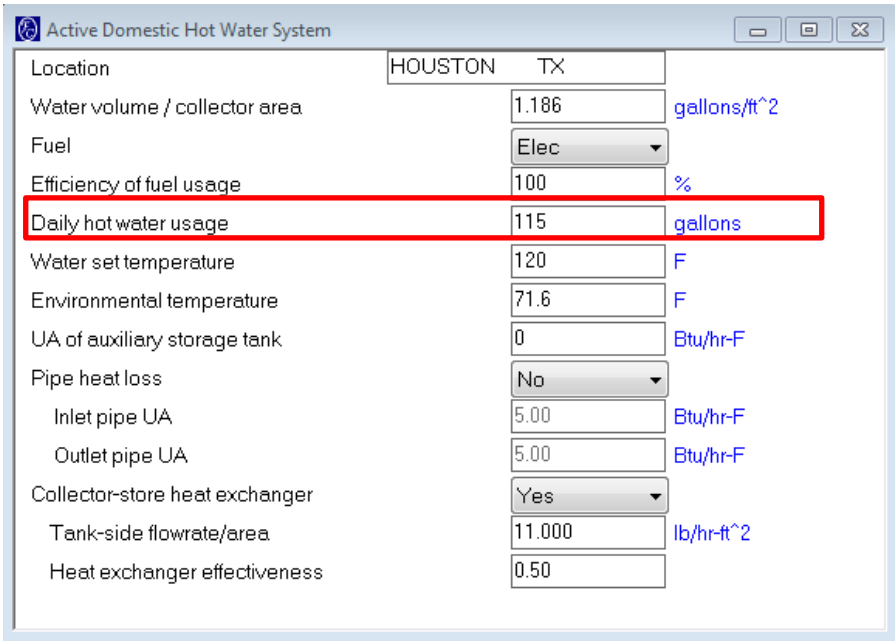
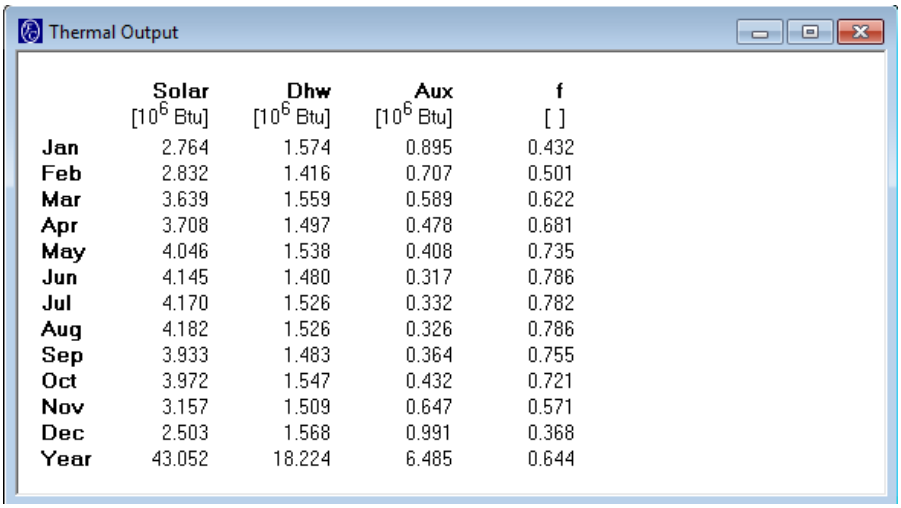


Figure 8-62 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	2.764	1.574	0.895	0.432
Feb	2.832	1.416	0.707	0.501
Mar	3.639	1.559	0.589	0.622
Apr	3.708	1.497	0.478	0.681
May	4.046	1.538	0.408	0.735
Jun	4.145	1.480	0.317	0.786
Jul	4.170	1.526	0.332	0.782
Aug	4.182	1.526	0.326	0.786
Sep	3.933	1.483	0.364	0.755
Oct	3.972	1.547	0.432	0.721
Nov	3.157	1.509	0.647	0.571
Dec	2.503	1.568	0.991	0.368
Year	43.052	18.224	6.485	0.644

Figure 8-63 F-Chart Simulation

8.8.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 8-64, Figure 8-65 and Figure 8-66.

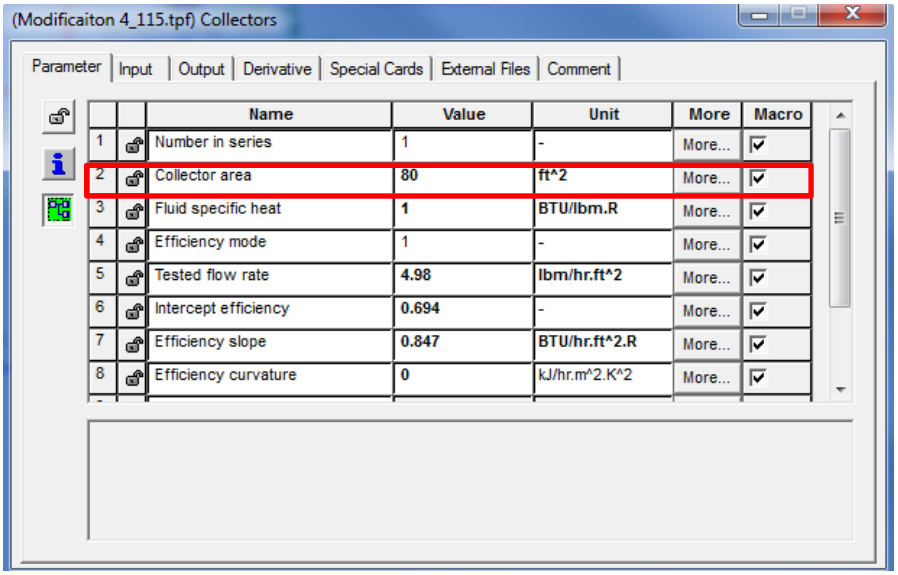


Figure 8-64 TRNSYS Component “Collectors” Settings

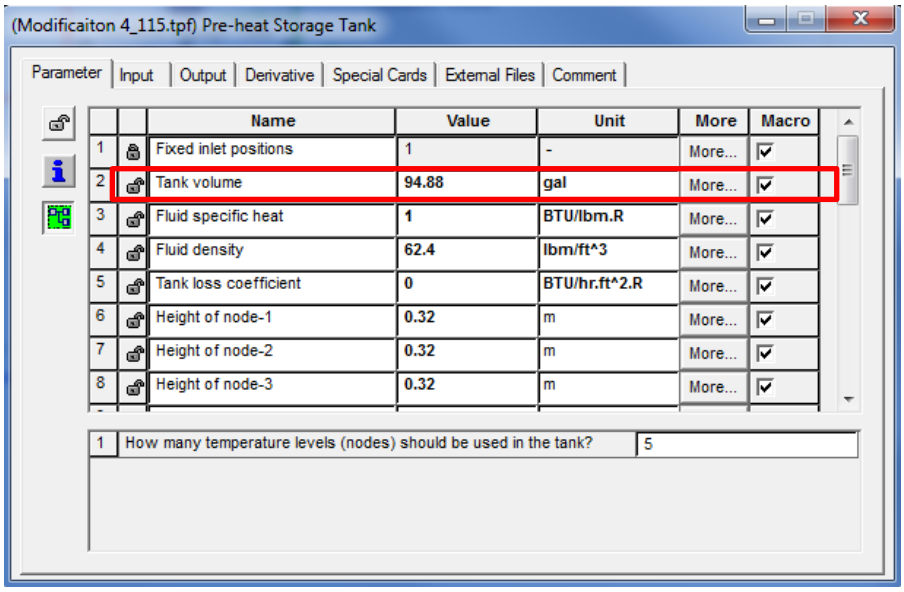


Figure 8-65 TRNSYS Component "Pre-heat Storage tank" Settings

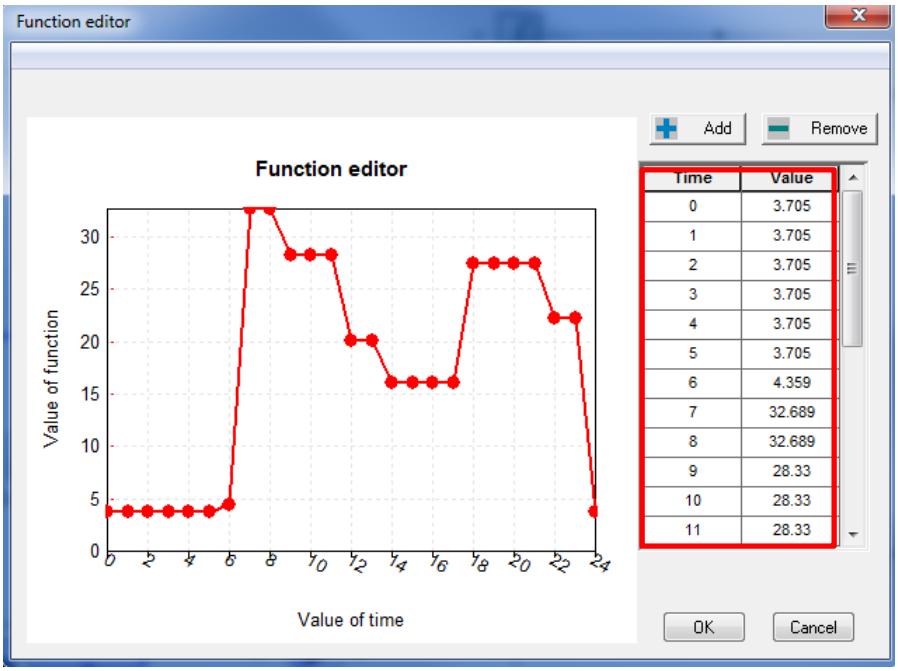


Figure 8-66 TRNSYS Component "Hot Water Demand" Settings

Figure 8-67 - Figure 8-70 present the simulation comparisons for ANALYSIS 4 (115 gallons/day) including Solar, Dhw, Aux and f factor. In Table 8-7, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw, Aux and f factor show a difference percentage of 0.4%, 35.1% and -19.6%, respectively.

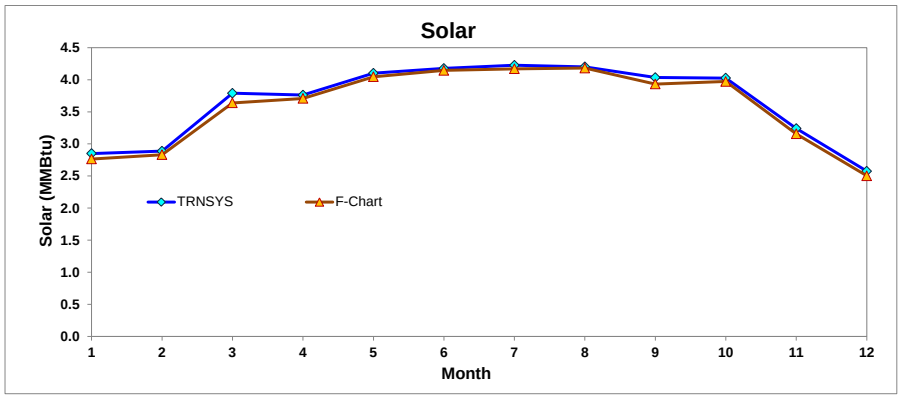


Figure 8-67 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 4 (115 gallons/day)

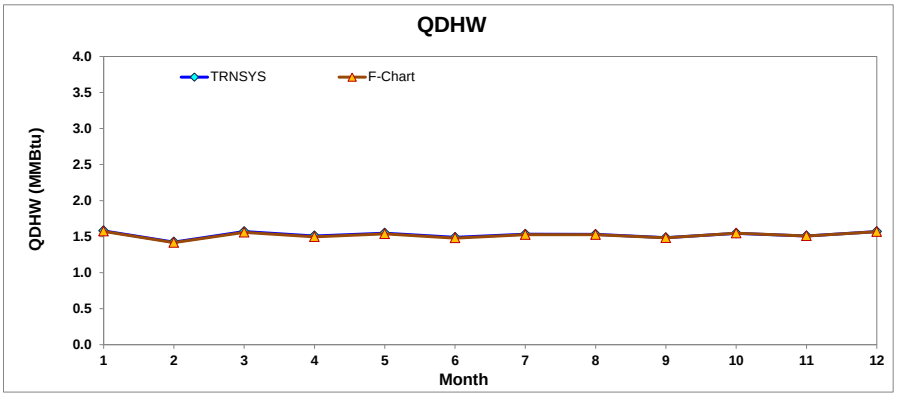


Figure 8-68Monthly Total Water Heating Demand -ANALYSIS 4 (115 gallons/day)

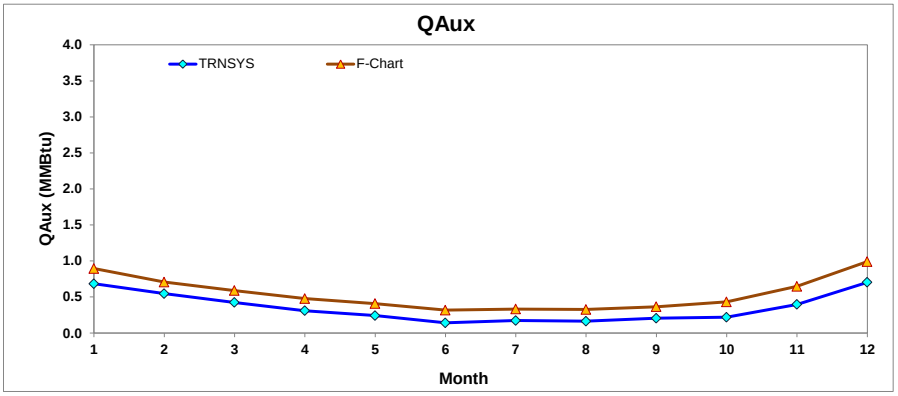


Figure 8-69Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 4 (115 gallons/day)

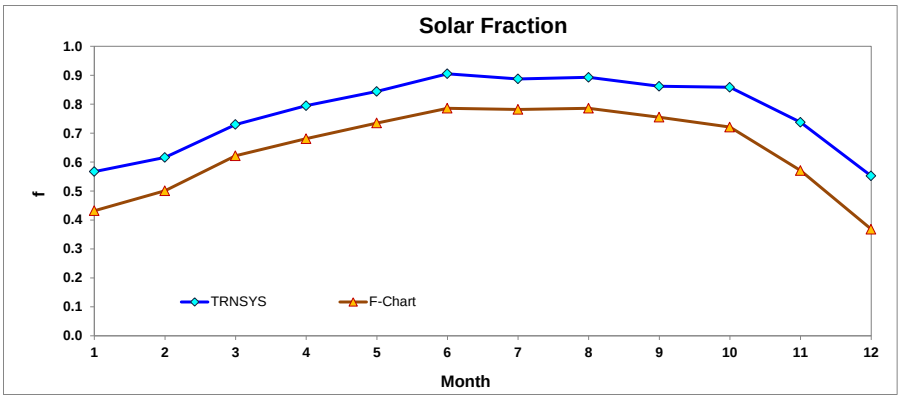


Figure 8-70Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 4 (115 gallons/day)

Table 8-7 Comparisons Data between TRNSYS and F-Chart ANALYSIS 4 (115 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	2.850	1.581	0.684	0.567	2.764	1.574	0.895	0.432	-3.1%	-0.4%	23.6%	-31.3%
Feb	2.888	1.424	0.547	0.616	2.832	1.416	0.707	0.501	-2.0%	0.6%	22.7%	-23.0%
Mar	3.789	1.569	0.424	0.730	3.639	1.559	0.589	0.622	-4.1%	0.7%	28.0%	-17.3%
Apr	3.762	1.509	0.309	0.795	3.708	1.497	0.478	0.681	-1.4%	0.8%	35.3%	-16.7%
May	4.101	1.549	0.241	0.844	4.046	1.538	0.408	0.735	-1.4%	0.7%	40.8%	-14.8%
Jun	4.176	1.490	0.141	0.905	4.145	1.480	0.317	0.786	-0.7%	0.7%	55.5%	-15.2%
Jul	4.225	1.534	0.173	0.887	4.170	1.526	0.332	0.782	-1.3%	0.5%	48.0%	-13.5%
Aug	4.200	1.531	0.164	0.893	4.182	1.526	0.326	0.786	-0.4%	0.3%	49.7%	-13.6%
Sep	4.035	1.486	0.205	0.862	3.933	1.483	0.364	0.755	-2.6%	0.2%	43.7%	-14.2%
Oct	4.025	1.546	0.219	0.859	3.972	1.547	0.432	0.721	-1.3%	0.1%	49.4%	-19.1%
Nov	3.241	1.509	0.396	0.738	3.157	1.509	0.647	0.571	-2.7%	0.0%	38.8%	-29.2%
Dec	2.575	1.569	0.703	0.552	2.503	1.568	0.991	0.368	-2.9%	0.1%	29.1%	-50.1%
Year	43.866	18.296	4.206	0.770	43.052	18.224	6.485	0.644	-1.9%	0.4%	35.1%	-19.6%

8.9 Discussion

Figure 8-71 compares the f factor of SDHW system simulated by TRNSYS and F-Chart. It has shown that both results follow similar pattern and trend. As the daily hot water usage increases, the f factor decreases. It has been noticed that TRNSYS still over predicts the useful solar in ANALYSIS 4. This gives the same conclusion as the ANALYSIS 1.

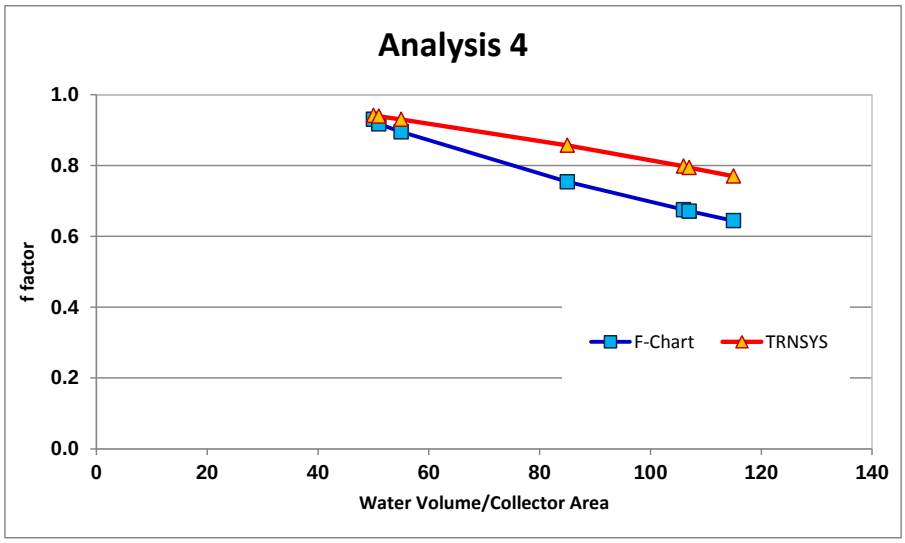


Figure 8-71 f Factor Comparisons between F-Chart and TRNSYS – ANALYSIS 4

9 SOLAR DOMESTIC HOT WATER SYSTEM SIMULATION COMPARISONS OF ANALYSIS 5 - DAILY HOT WATER USAGE STUDY PART II

9.1 Overview

Starting from this section, different case studies are performed to further checking the simulation accuracy of TRNSYS program on SDHW System. This section will vary the total collector area from 64.02 ft^2 to 800 ft^2. With 800ft^2 total solar collector area, the daily hot water usage is varied by 10,25,55,85,115,146,147 and 150 gallons/day. The other settings are kept as the same as base case.

9.2 Analysis 5-10 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 10 gallons/day with the storage tank volume 948.8 gallons.

9.2.1 F-Chart simulation

Figure 9-1 and Figure 9-2 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-3gives the result summary of modified simulation.

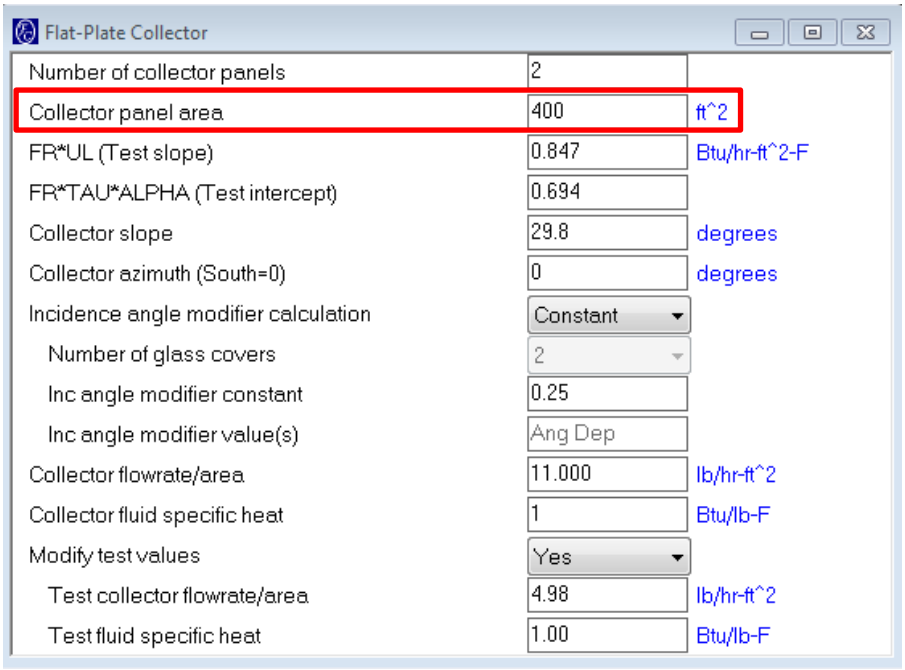


Figure 9-1 Flat-Plate Collector Input

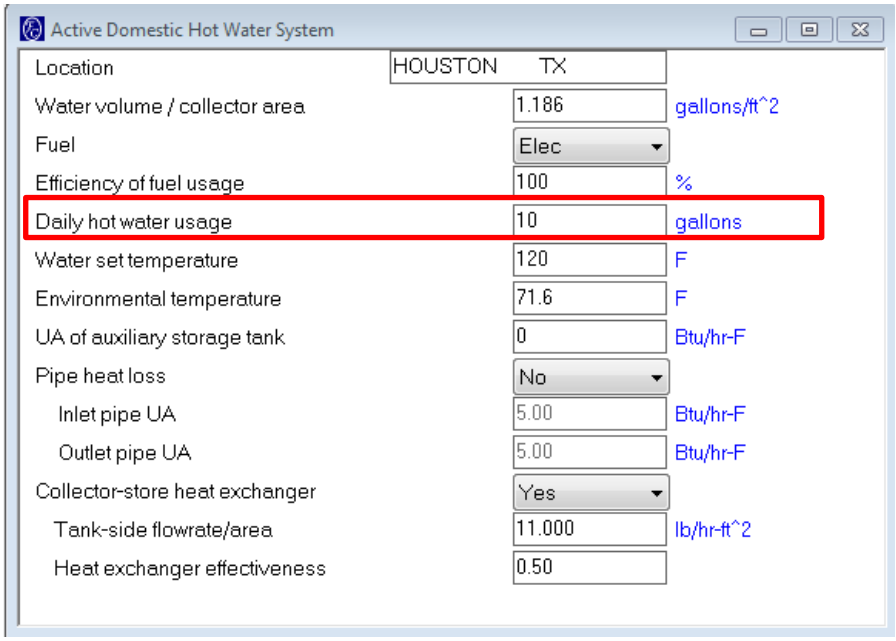
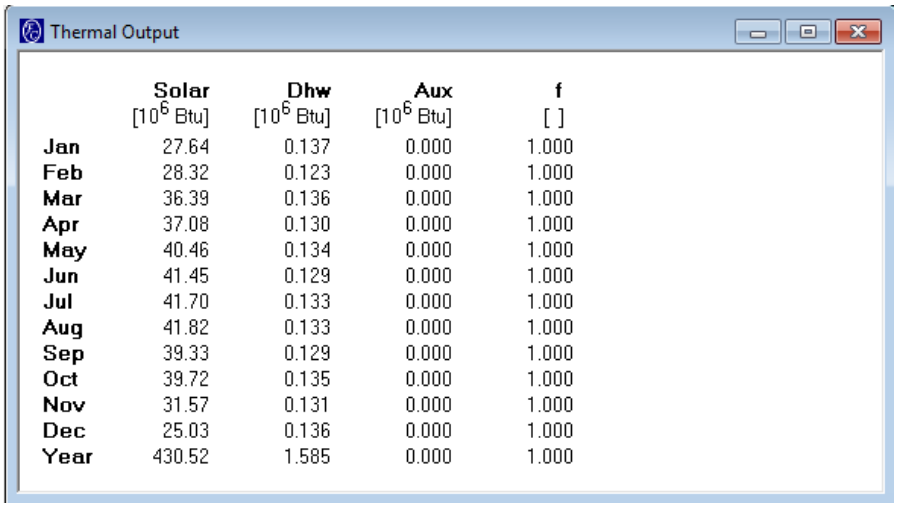


Figure 9-2 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	0.137	0.000	1.000
Feb	28.32	0.123	0.000	1.000
Mar	36.39	0.136	0.000	1.000
Apr	37.08	0.130	0.000	1.000
May	40.46	0.134	0.000	1.000
Jun	41.45	0.129	0.000	1.000
Jul	41.70	0.133	0.000	1.000
Aug	41.82	0.133	0.000	1.000
Sep	39.33	0.129	0.000	1.000
Oct	39.72	0.135	0.000	1.000
Nov	31.57	0.131	0.000	1.000
Dec	25.03	0.136	0.000	1.000
Year	430.52	1.585	0.000	1.000

Figure 9-3 F-Chart Simulation

9.2.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-4 , Figure 9-5 and Figure 9-6.

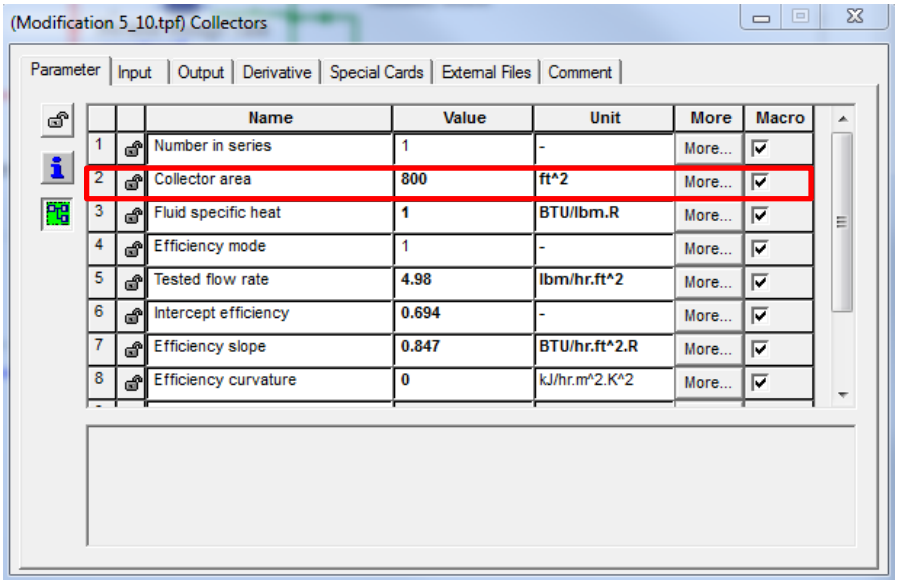


Figure 9-4 TRNSYS Component “Collectors” Settings

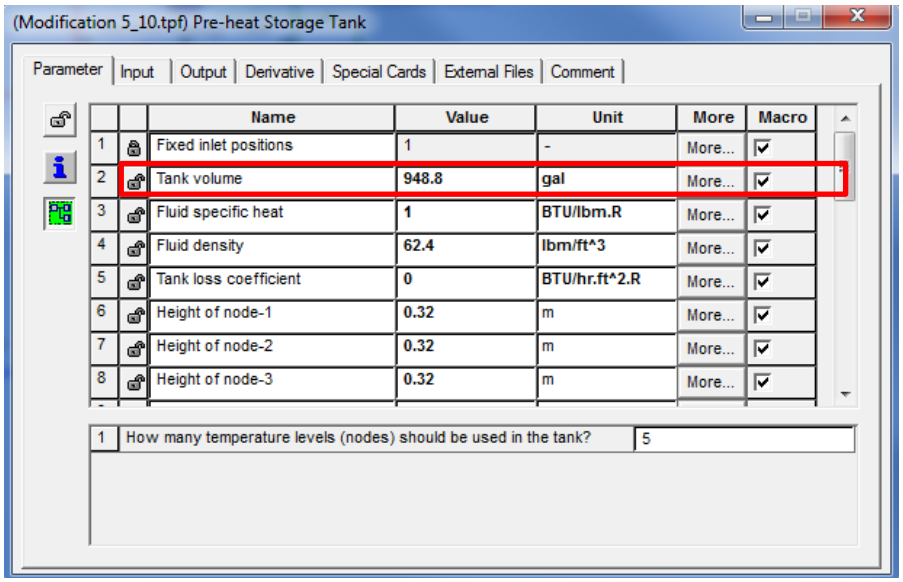


Figure 9-5 TRNSYS Component "Pre-heat Storage tank" Settings

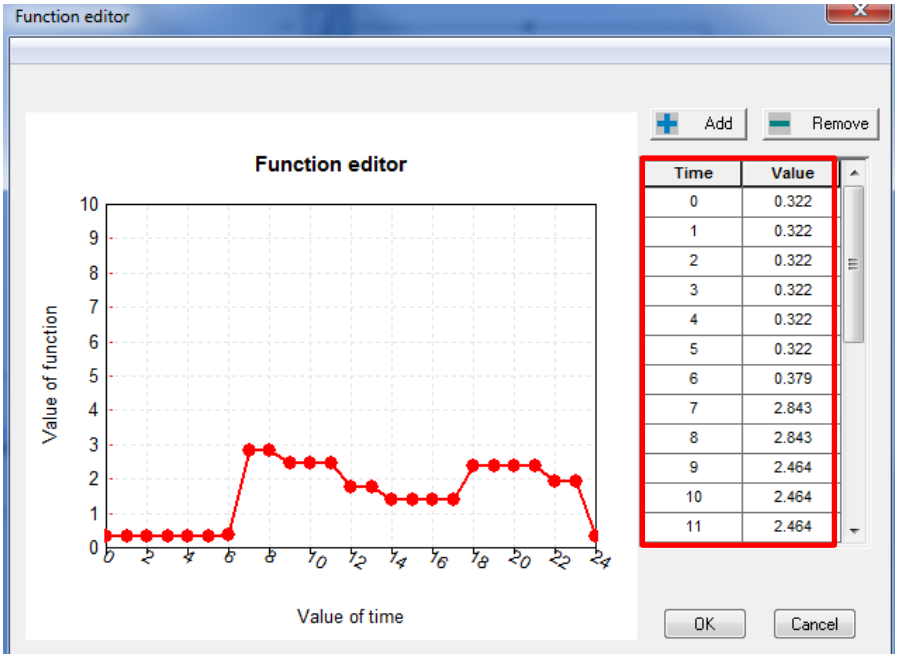


Figure 9-6 TRNSYS Component "Hot Water Demand" Settings

Figure 9-7 - Figure 9-10 present the simulation comparisons for ANALYSIS 5 (10 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-1, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

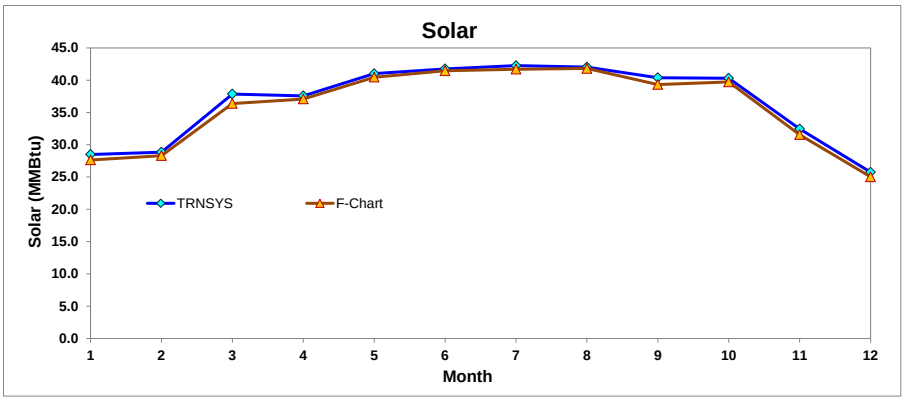


Figure 9-7 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (10 gallons/day)

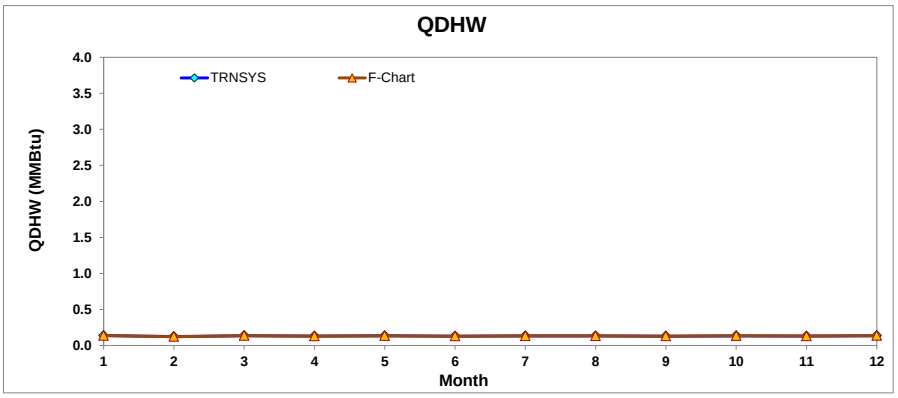


Figure 9-8Monthly Total Water Heating Demand -ANALYSIS 5 (10 gallons/day)

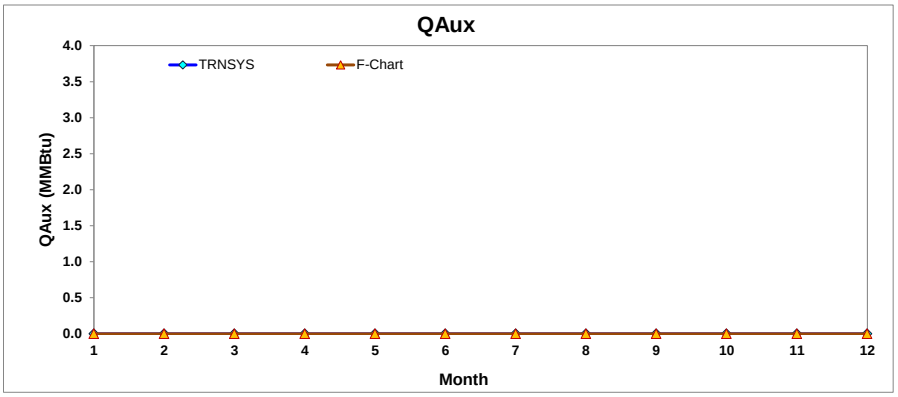


Figure 9-9Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (10 gallons/day)

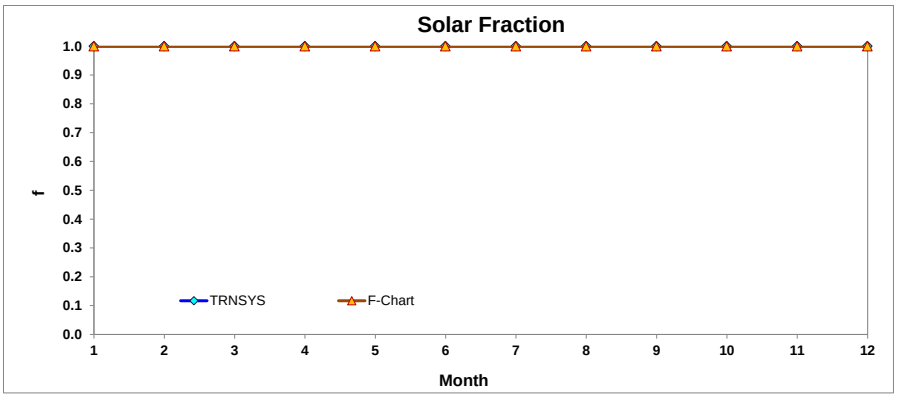


Figure 9-10Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (10 gallons/day)

Table 9-1 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (10 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	0.138	0.000	1.000	27.640	0.137	0.000	1.000	-3.1%	-0.4%	N/A	0.0%
Feb	28.856	0.124	0.000	1.000	28.320	0.123	0.000	1.000	-1.9%	0.7%	N/A	0.0%
Mar	37.856	0.136	0.000	1.000	36.390	0.136	0.000	1.000	-4.0%	0.4%	N/A	0.0%
Apr	37.573	0.131	0.000	1.000	37.080	0.130	0.000	1.000	-1.3%	0.9%	N/A	0.0%
May	41.013	0.135	0.000	1.000	40.460	0.134	0.000	1.000	-1.4%	0.5%	N/A	0.0%
Jun	41.751	0.130	0.000	1.000	41.450	0.129	0.000	1.000	-0.7%	0.4%	N/A	0.0%
Jul	42.258	0.133	0.000	1.000	41.700	0.133	0.000	1.000	-1.3%	0.3%	N/A	0.0%
Aug	42.033	0.133	0.000	1.000	41.820	0.133	0.000	1.000	-0.5%	0.1%	N/A	0.0%
Sep	40.389	0.129	0.000	1.000	39.330	0.129	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	0.134	0.000	1.000	39.720	0.135	0.000	1.000	-1.5%	0.4%	N/A	0.0%
Nov	32.452	0.131	0.000	1.000	31.570	0.131	0.000	1.000	-2.8%	0.2%	N/A	0.0%
Dec	25.754	0.136	0.000	1.000	25.030	0.136	0.000	1.000	-2.9%	0.4%	N/A	0.0%
Year	438.730	1.591	0.000	1.000	430.520	1.585	0.000	1.000	-1.9%	0.4%	N/A	0.0%

9.3 Analysis 5-25 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 25 gallons/day with the storage tank volume 948.8 gallons.

9.3.1 F-Chart simulation

Figure 9-11 and Figure 9-12 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-13 gives the result summary of modified simulation.

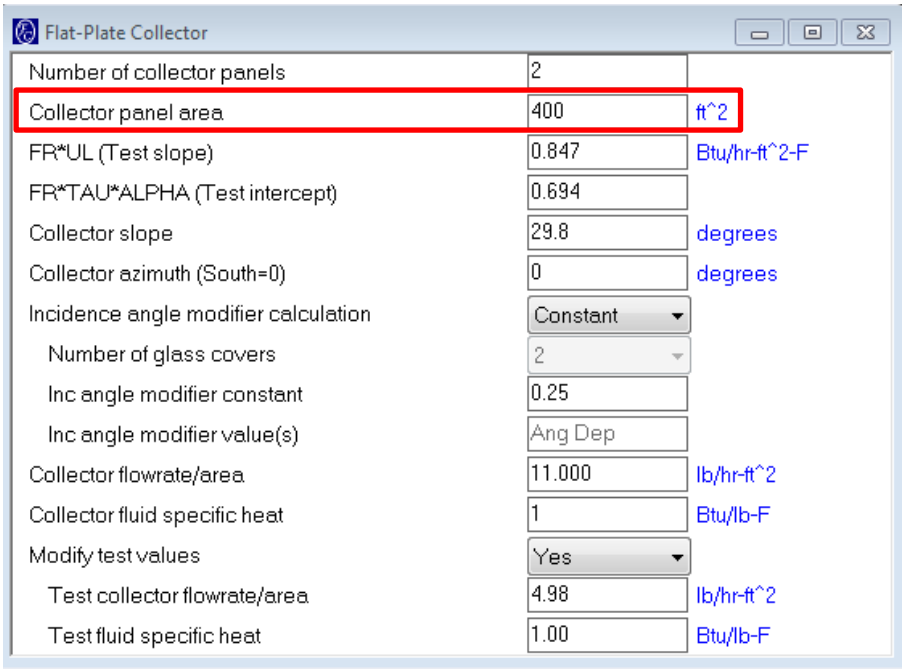


Figure 9-11 Flat-Plate Collector Input

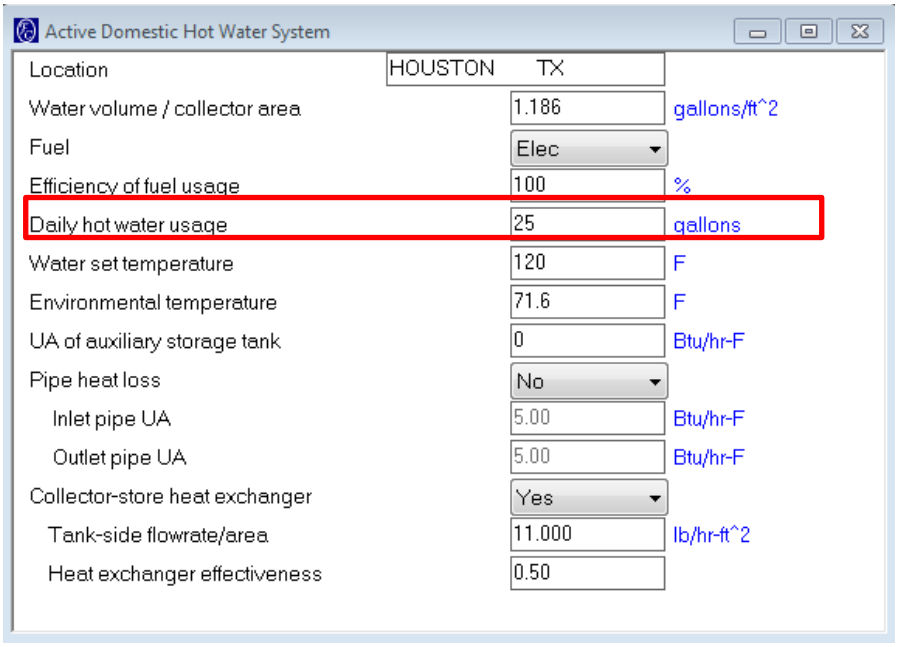
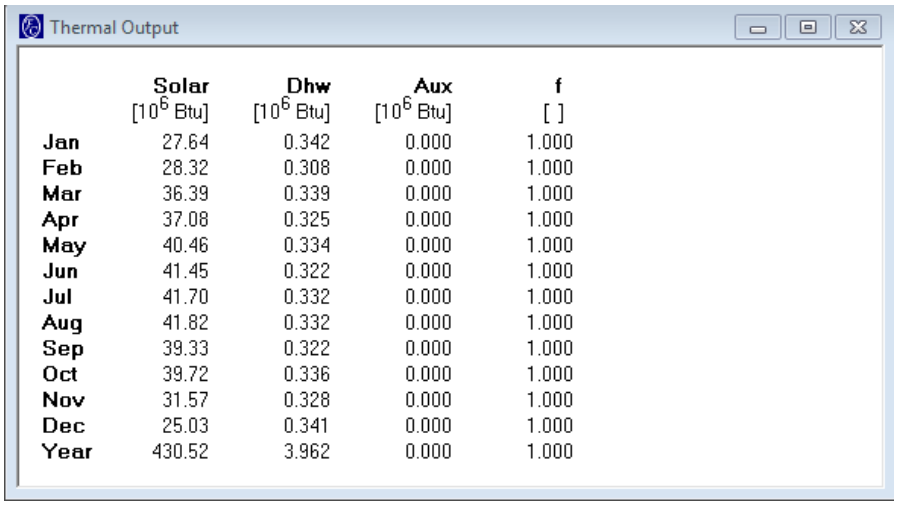


Figure 9-12 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	0.342	0.000	1.000
Feb	28.32	0.308	0.000	1.000
Mar	36.39	0.339	0.000	1.000
Apr	37.08	0.325	0.000	1.000
May	40.46	0.334	0.000	1.000
Jun	41.45	0.322	0.000	1.000
Jul	41.70	0.332	0.000	1.000
Aug	41.82	0.332	0.000	1.000
Sep	39.33	0.322	0.000	1.000
Oct	39.72	0.336	0.000	1.000
Nov	31.57	0.328	0.000	1.000
Dec	25.03	0.341	0.000	1.000
Year	430.52	3.962	0.000	1.000

Figure 9-13 F-Chart Simulation

9.3.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-14,Figure 9-15 and Figure 9-16.

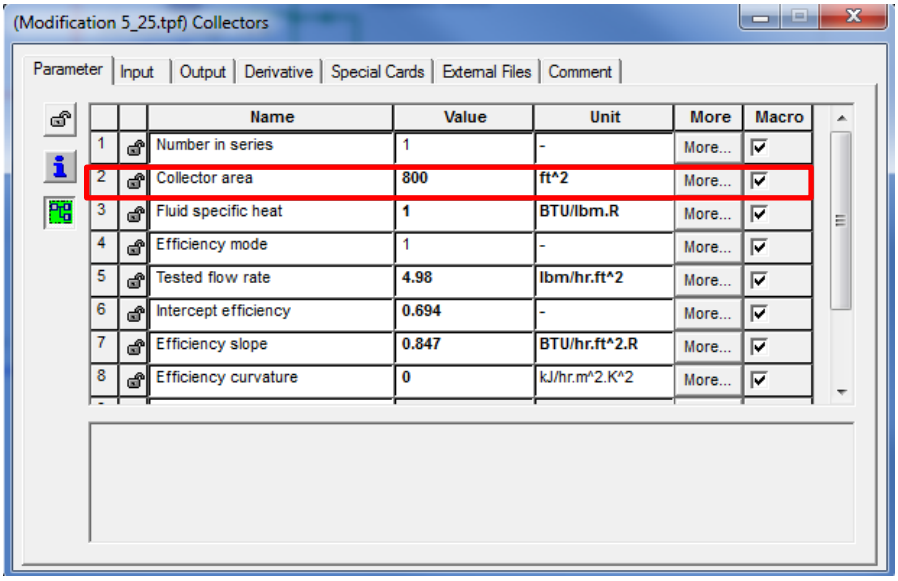


Figure 9-14 TRNSYS Component “Collectors” Settings

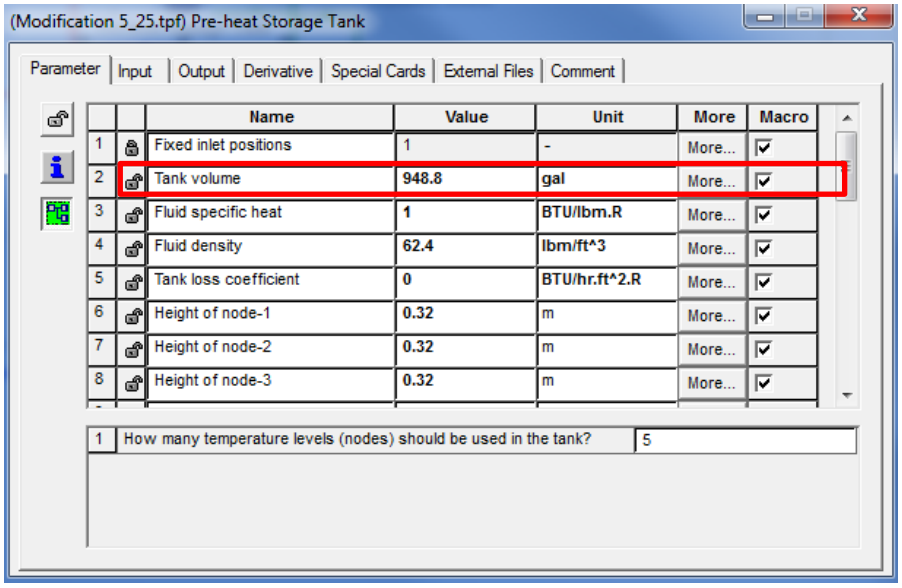


Figure 9-15 TRNSYS Component "Pre-heat Storage tank" Settings

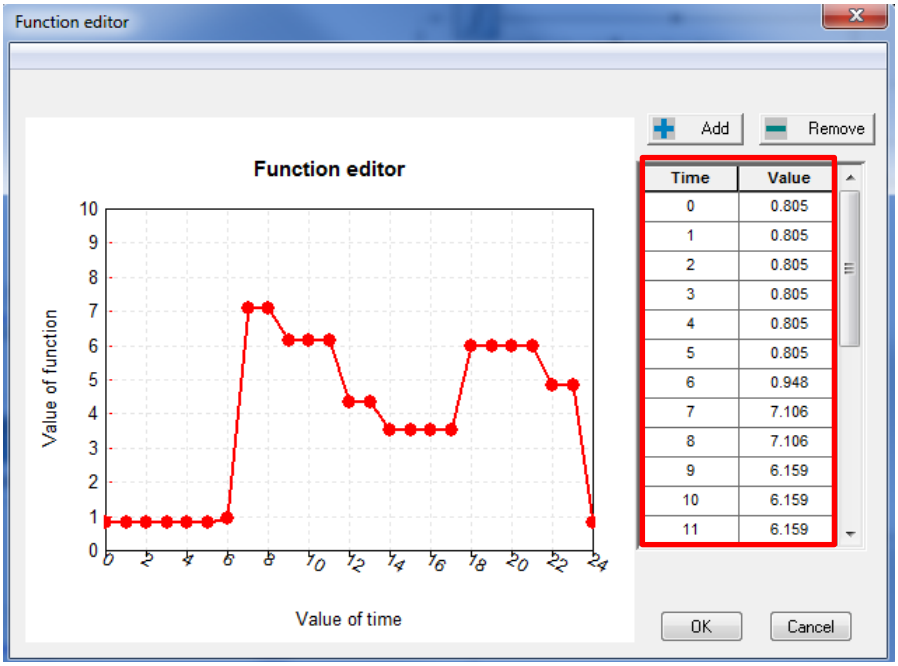


Figure 9-16 TRNSYS Component "Hot Water Demand" Settings

Figure 9-17 - Figure 9-20 present the simulation comparisons for ANALYSIS 5 (25 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-2, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

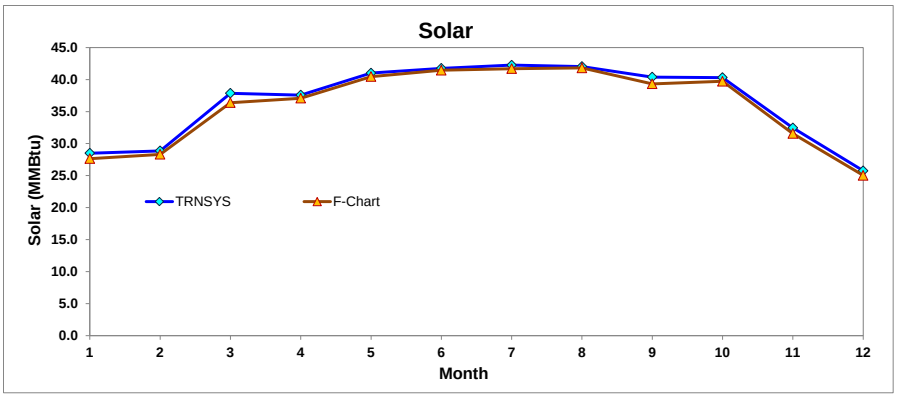


Figure 9-17 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (25 gallons/day)

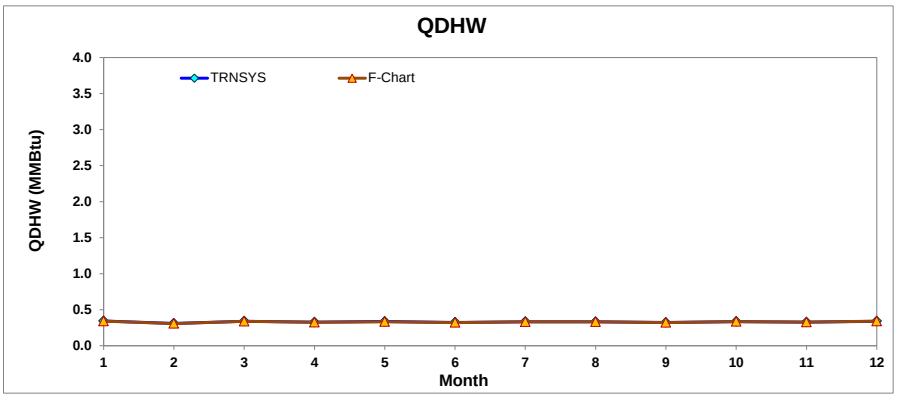


Figure 9-18Monthly Total Water Heating Demand -ANALYSIS 5 (25 gallons/day)

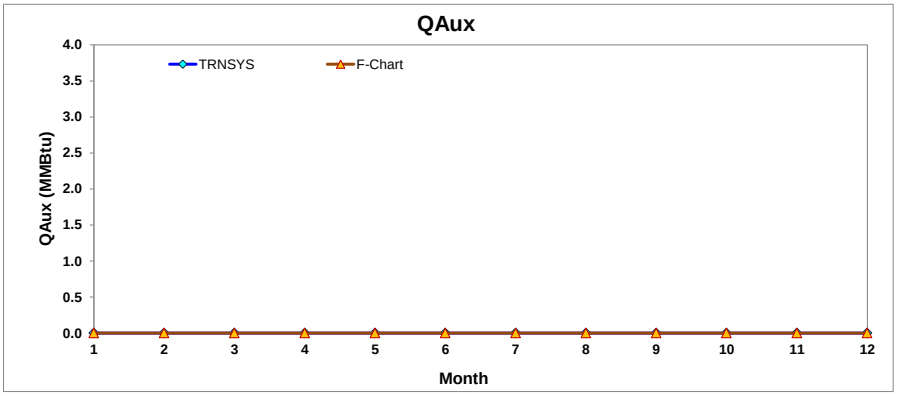


Figure 9-19Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (25 gallons/day)

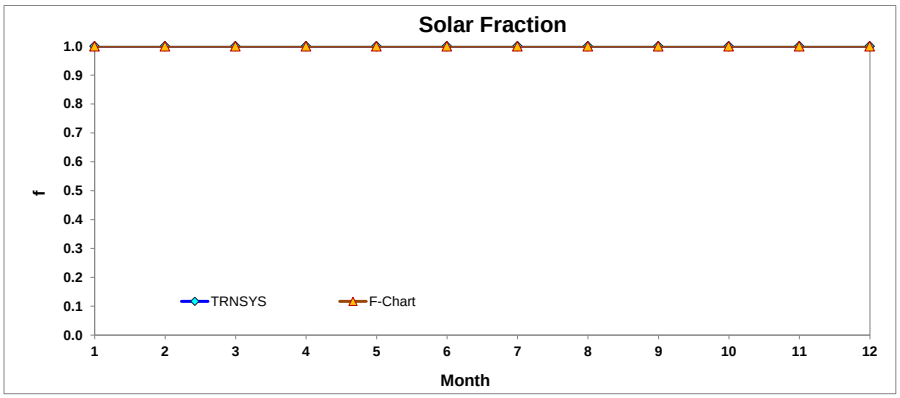


Figure 9-20Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (25 gallons/day)

Table 9-2 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (25 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	0.344	0.000	1.000	27.640	0.342	0.000	1.000	-3.1%	-0.5%	N/A	0.0%
Feb	28.856	0.310	0.000	1.000	28.320	0.308	0.000	1.000	-1.9%	0.7%	N/A	0.0%
Mar	37.856	0.341	0.000	1.000	36.390	0.339	0.000	1.000	-4.0%	0.5%	N/A	0.0%
Apr	37.573	0.328	0.000	1.000	37.080	0.325	0.000	1.000	-1.3%	0.9%	N/A	0.0%
May	41.013	0.337	0.000	1.000	40.460	0.334	0.000	1.000	-1.4%	0.8%	N/A	0.0%
Jun	41.751	0.324	0.000	1.000	41.450	0.322	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.258	0.333	0.000	1.000	41.700	0.332	0.000	1.000	-1.3%	0.3%	N/A	0.0%
Aug	42.033	0.332	0.000	1.000	41.820	0.332	0.000	1.000	-0.5%	0.0%	N/A	0.0%
Sep	40.389	0.323	0.000	1.000	39.330	0.322	0.000	1.000	-2.7%	0.4%	N/A	0.0%
Oct	40.300	0.336	0.000	1.000	39.720	0.336	0.000	1.000	-1.5%	0.0%	N/A	0.0%
Nov	32.452	0.328	0.000	1.000	31.570	0.328	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	25.754	0.341	0.000	1.000	25.030	0.341	0.000	1.000	-2.9%	0.0%	N/A	0.0%
Year	438.730	3.977	0.000	1.000	430.520	3.962	0.000	1.000	-1.9%	0.4%	N/A	0.0%

9.4 Analysis 5-55 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 55 gallons/day with the storage tank volume 948.8 gallons.

9.4.1 F-Chart simulation

Figure 9-21 and Figure 9-22 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-23 gives the result summary of modified simulation.

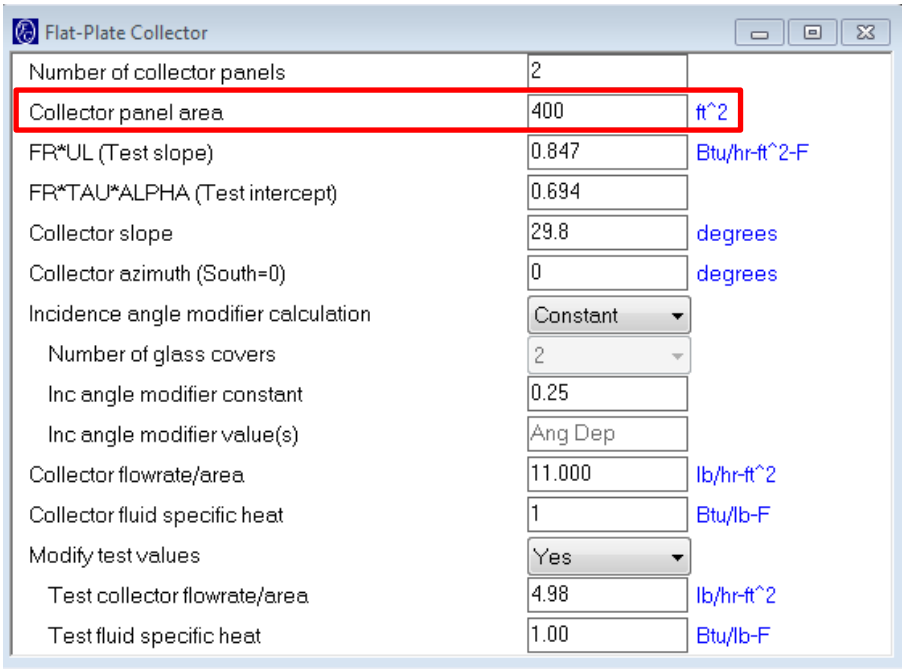


Figure 9-21 Flat-Plate Collector Input

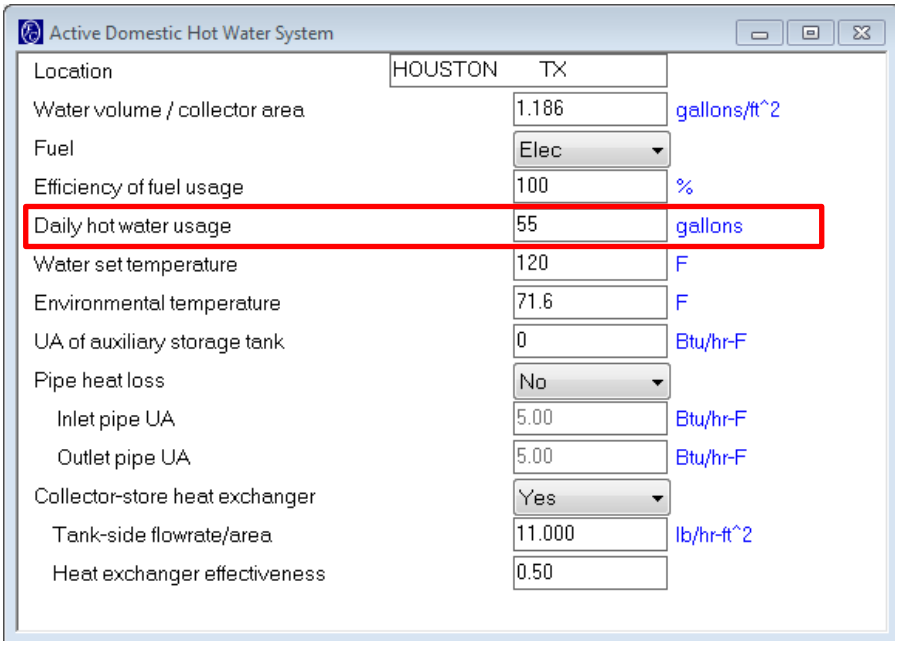
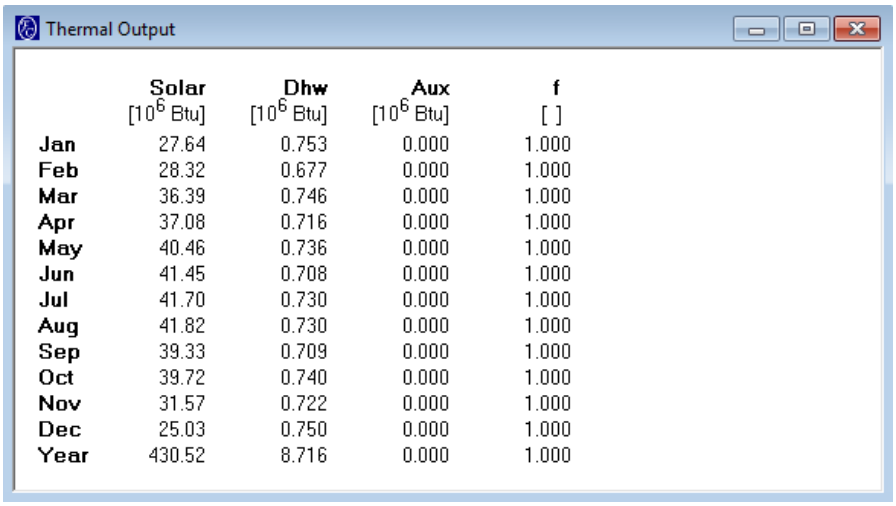


Figure 9-22 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	0.753	0.000	1.000
Feb	28.32	0.677	0.000	1.000
Mar	36.39	0.746	0.000	1.000
Apr	37.08	0.716	0.000	1.000
May	40.46	0.736	0.000	1.000
Jun	41.45	0.708	0.000	1.000
Jul	41.70	0.730	0.000	1.000
Aug	41.82	0.730	0.000	1.000
Sep	39.33	0.709	0.000	1.000
Oct	39.72	0.740	0.000	1.000
Nov	31.57	0.722	0.000	1.000
Dec	25.03	0.750	0.000	1.000
Year	430.52	8.716	0.000	1.000

Figure 9-23 F-Chart Simulation

9.4.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-24, Figure 9-25 and Figure 9-26.

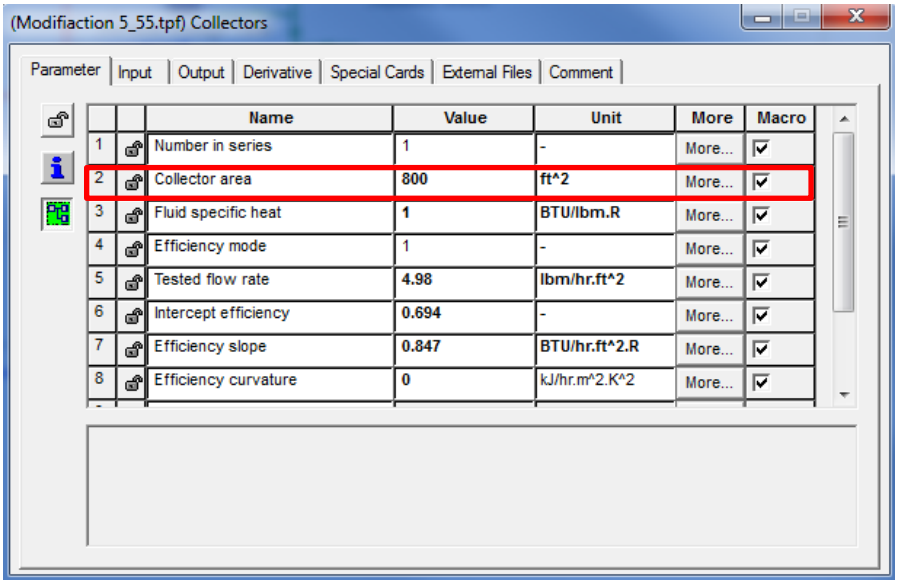


Figure 9-24 TRNSYS Component “Collectors” Settings

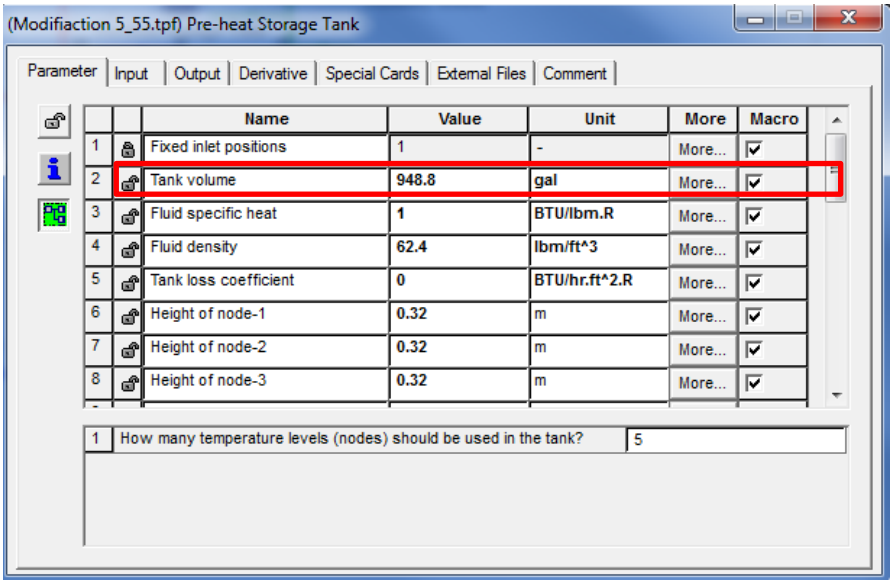


Figure 9-25 TRNSYS Component "Pre-heat Storage tank" Settings

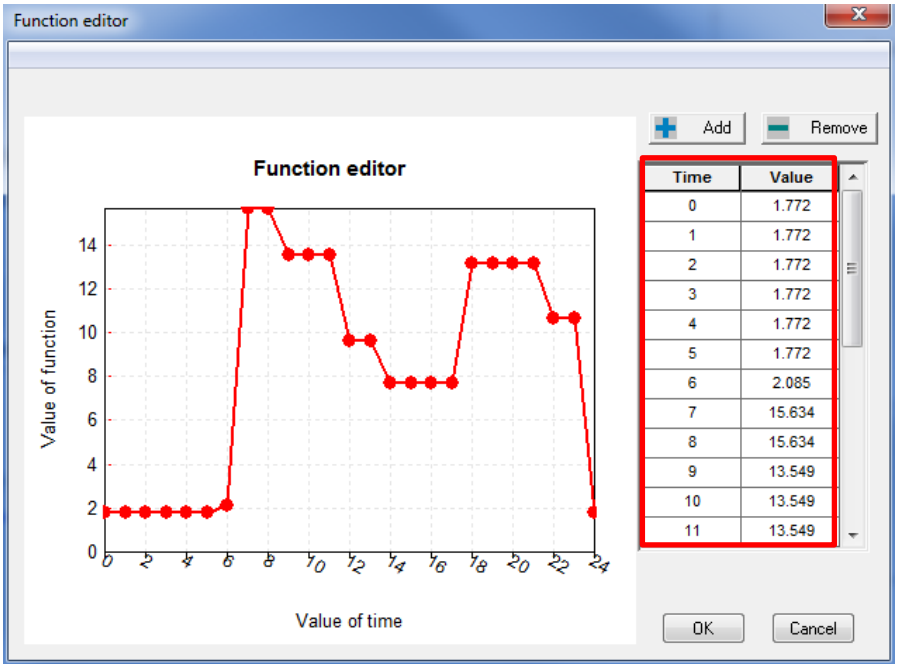


Figure 9-26 TRNSYS Component "Hot Water Demand" Settings

Figure 9-27 - Figure 9-30 present the simulation comparisons for ANALYSIS 5 (55 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-3, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

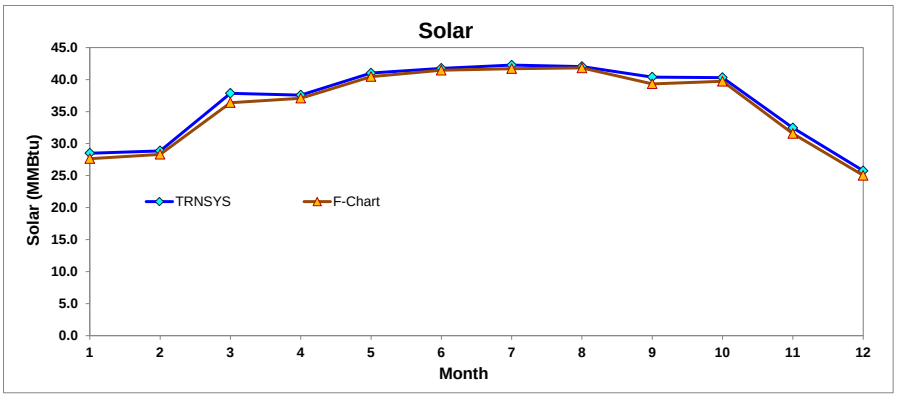


Figure 9-27 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (55 gallons/day)

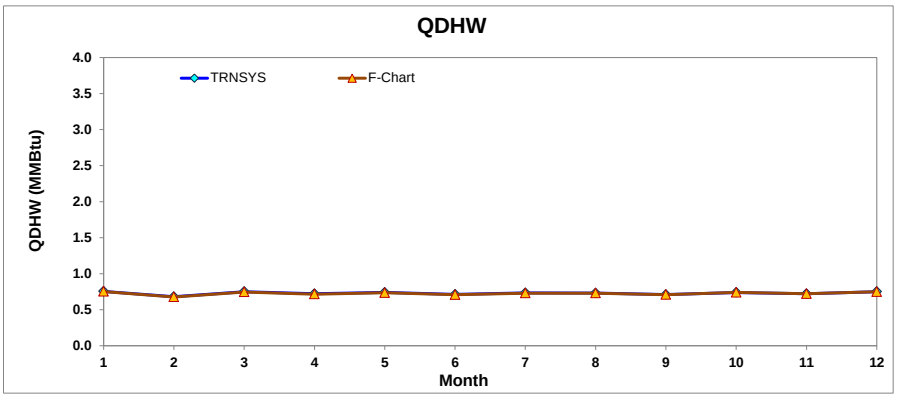


Figure 9-28Monthly Total Water Heating Demand -ANALYSIS 5 (55 gallons/day)

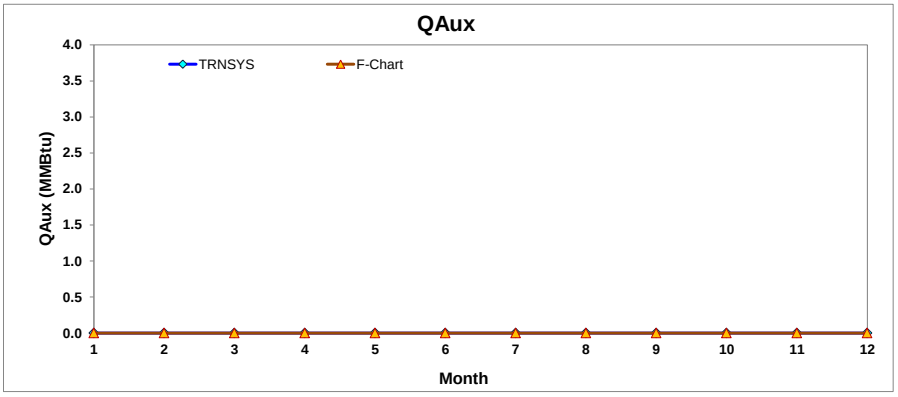


Figure 9-29Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (55 gallons/day)

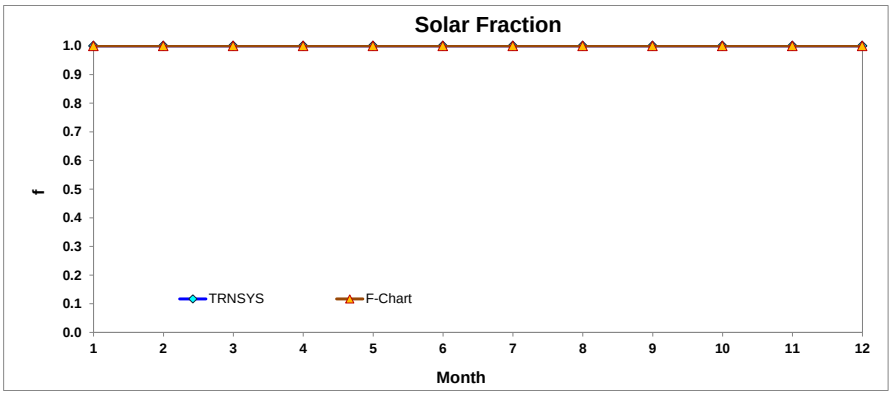


Figure 9-30Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (55 gallons/day)

Table 9-3 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (55 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	0.755	0.000	1.000	27.640	0.753	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	28.856	0.681	0.000	1.000	28.320	0.677	0.000	1.000	-1.9%	0.6%	N/A	0.0%
Mar	37.856	0.751	0.000	1.000	36.390	0.746	0.000	1.000	-4.0%	0.6%	N/A	0.0%
Apr	37.573	0.722	0.000	1.000	37.080	0.716	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	41.013	0.741	0.000	1.000	40.460	0.736	0.000	1.000	-1.4%	0.6%	N/A	0.0%
Jun	41.751	0.712	0.000	1.000	41.450	0.708	0.000	1.000	-0.7%	0.6%	N/A	0.0%
Jul	42.258	0.734	0.000	1.000	41.700	0.730	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.033	0.732	0.000	1.000	41.820	0.730	0.000	1.000	-0.5%	0.2%	N/A	0.0%
Sep	40.389	0.711	0.000	1.000	39.330	0.709	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	0.739	0.000	1.000	39.720	0.740	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	32.452	0.722	0.000	1.000	31.570	0.722	0.000	1.000	-2.8%	0.1%	N/A	0.0%
Dec	25.754	0.751	0.000	1.000	25.030	0.750	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.730	8.750	0.000	1.000	430.520	8.716	0.000	1.000	-1.9%	0.4%	N/A	0.0%

9.5 Analysis 5-85 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 85 gallons/day with the storage tank volume 948.8 gallons.

9.5.1 F-Chart simulation

Figure 9-31 and Figure 9-32 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-33 gives the result summary of modified simulation.

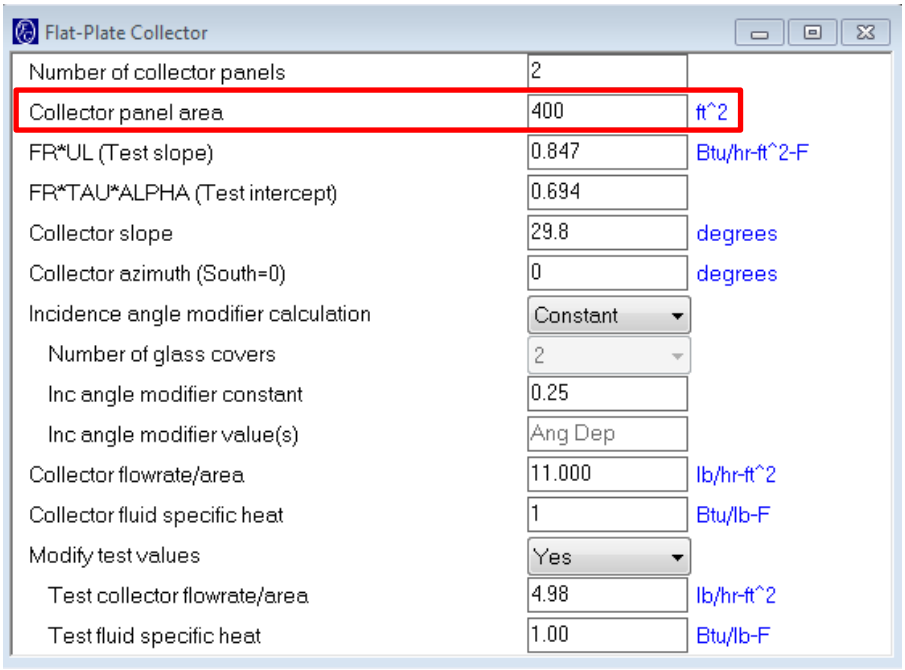


Figure 9-31 Flat-Plate Collector Input

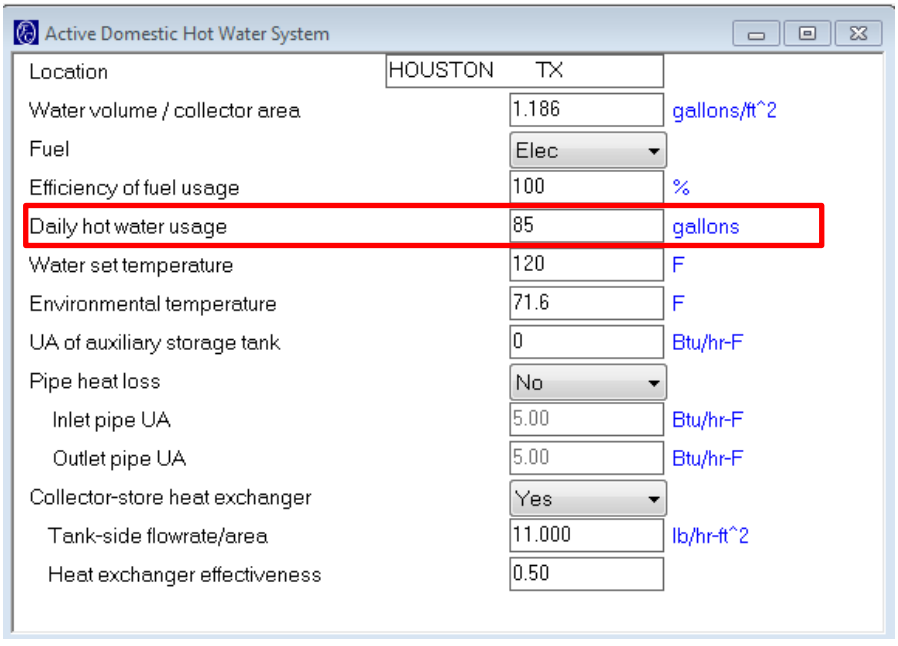
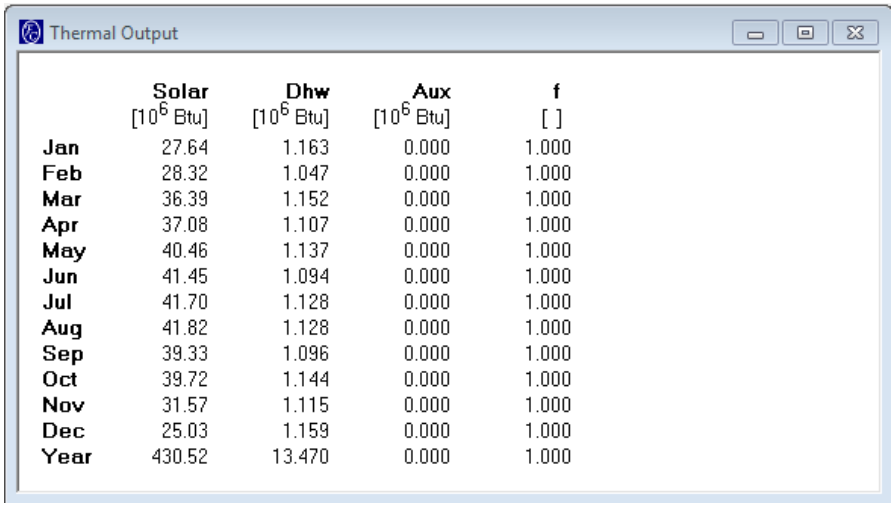


Figure 9-32 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	1.163	0.000	1.000
Feb	28.32	1.047	0.000	1.000
Mar	36.39	1.152	0.000	1.000
Apr	37.08	1.107	0.000	1.000
May	40.46	1.137	0.000	1.000
Jun	41.45	1.094	0.000	1.000
Jul	41.70	1.128	0.000	1.000
Aug	41.82	1.128	0.000	1.000
Sep	39.33	1.096	0.000	1.000
Oct	39.72	1.144	0.000	1.000
Nov	31.57	1.115	0.000	1.000
Dec	25.03	1.159	0.000	1.000
Year	430.52	13.470	0.000	1.000

Figure 9-33 F-Chart Simulation

9.5.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-34, Figure 9-35 and Figure 9-36.

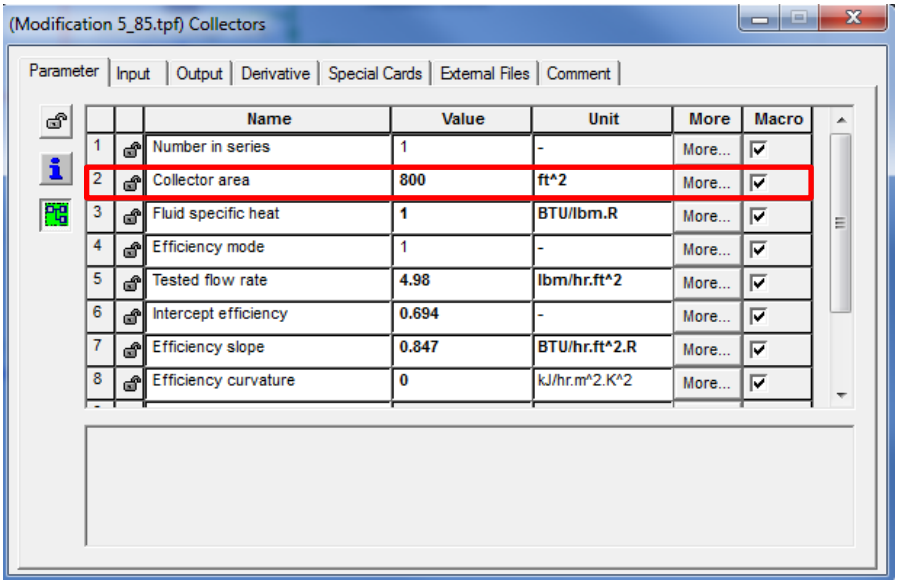


Figure 9-34 TRNSYS Component “Collectors” Settings

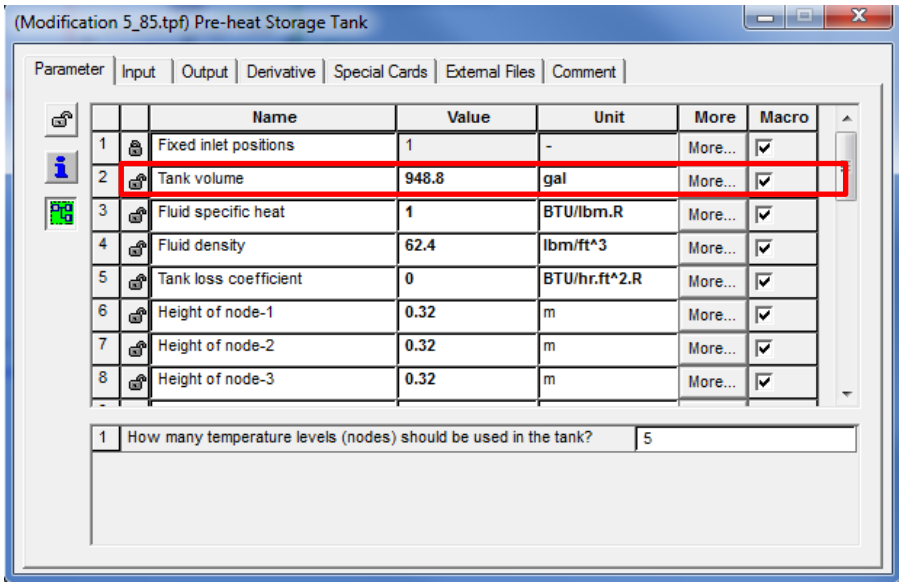


Figure 9-35 TRNSYS Component "Pre-heat Storage tank" Settings

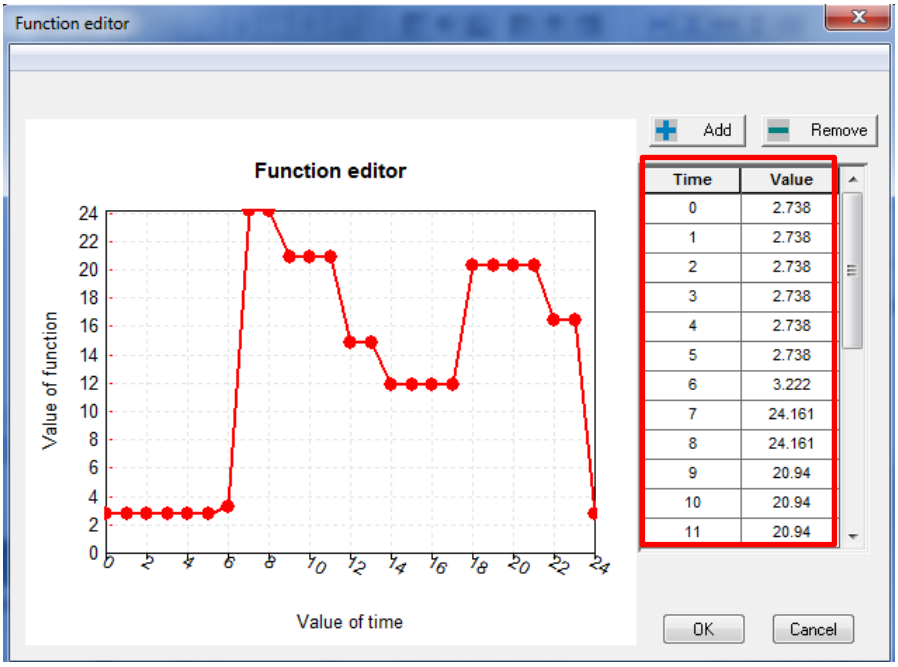


Figure 9-36 TRNSYS Component "Hot Water Demand" Settings

Figure 9-37 - Figure 9-40 present the simulation comparisons for ANALYSIS 5 (85 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-4, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

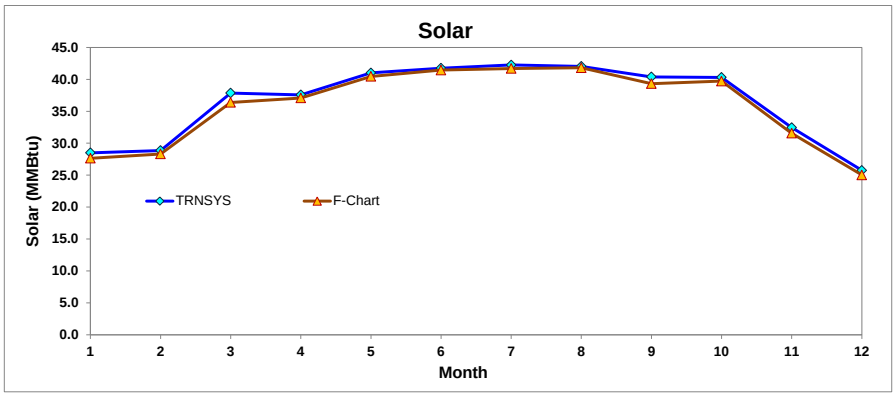


Figure 9-37 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (85 gallons/day)

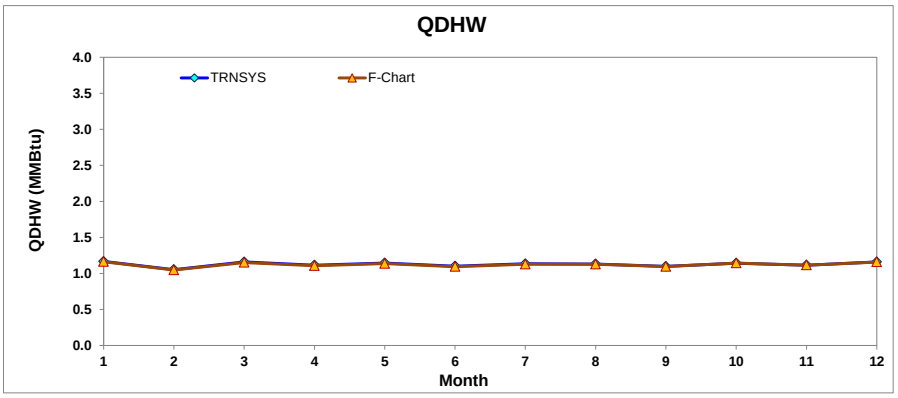


Figure 9-38Monthly Total Water Heating Demand -ANALYSIS 5 (85 gallons/day)

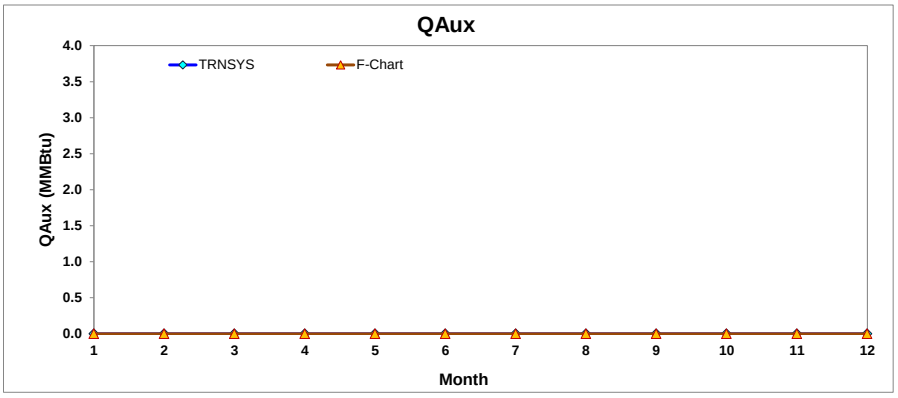


Figure 9-39Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (85 gallons/day)

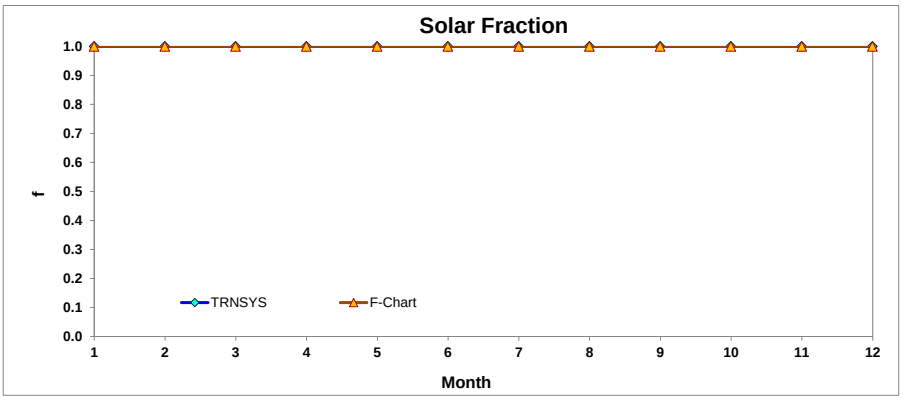


Figure 9-40Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (85 gallons/day)

Table 9-4 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (85 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	1.166	0.000	1.000	27.640	1.163	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	28.856	1.053	0.000	1.000	28.320	1.047	0.000	1.000	-1.9%	0.5%	N/A	0.0%
Mar	37.856	1.160	0.000	1.000	36.390	1.152	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	37.573	1.115	0.000	1.000	37.080	1.107	0.000	1.000	-1.3%	0.7%	N/A	0.0%
May	41.013	1.145	0.000	1.000	40.460	1.137	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.751	1.101	0.000	1.000	41.450	1.094	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.258	1.134	0.000	1.000	41.700	1.128	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.033	1.131	0.000	1.000	41.820	1.128	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	40.389	1.098	0.000	1.000	39.330	1.096	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	1.142	0.000	1.000	39.720	1.144	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	32.452	1.115	0.000	1.000	31.570	1.115	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	25.754	1.160	0.000	1.000	25.030	1.159	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.730	13.522	0.000	1.000	430.520	13.470	0.000	1.000	-1.9%	0.4%	N/A	0.0%

9.6 Analysis 5-115 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 115 gallons/day with the storage tank volume 948.8 gallons.

9.6.1 F-Chart simulation

Figure 9-41 and Figure 9-42 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-43 gives the result summary of modified simulation.

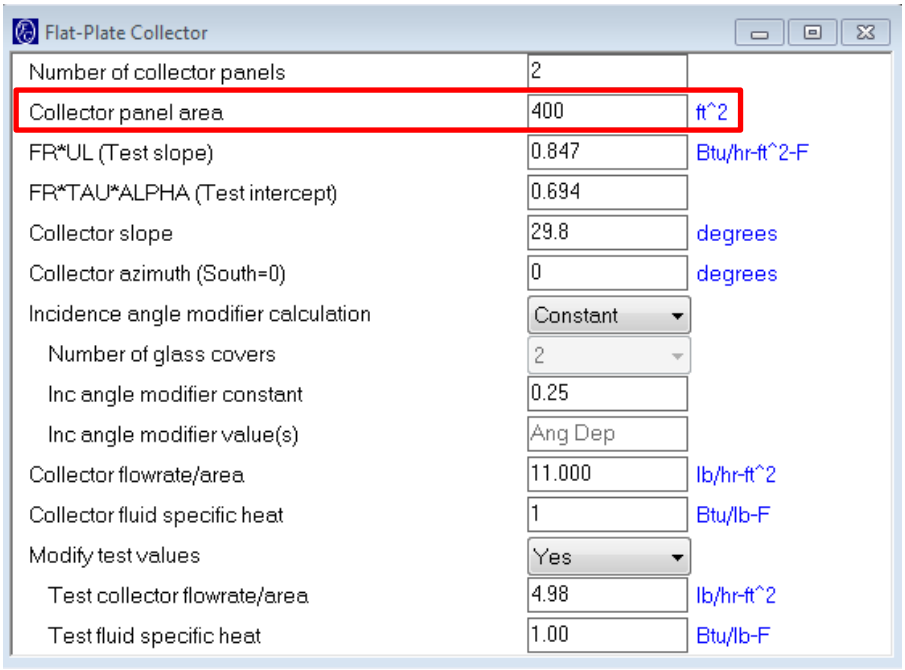


Figure 9-41 Flat-Plate Collector Input

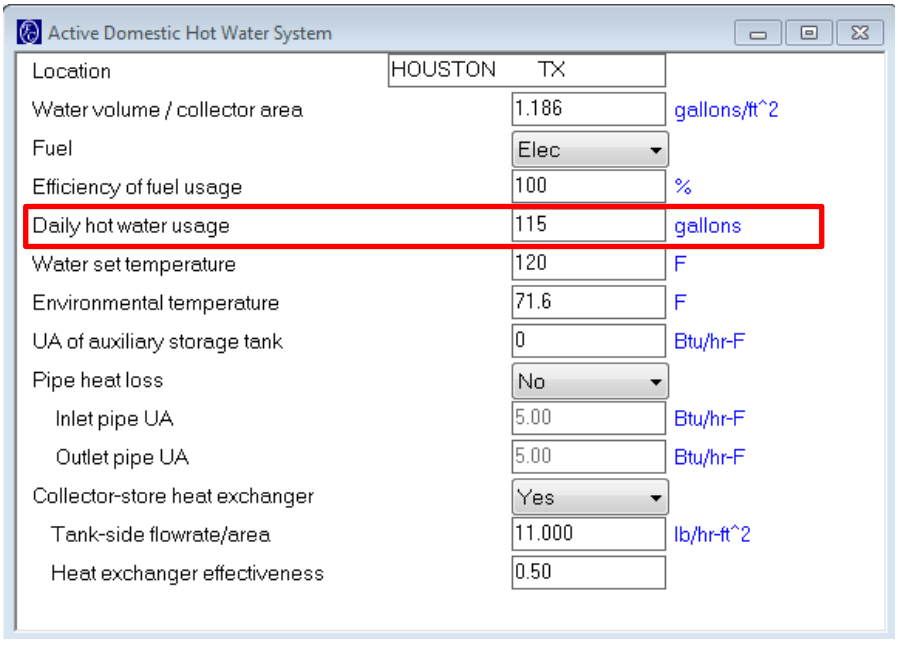
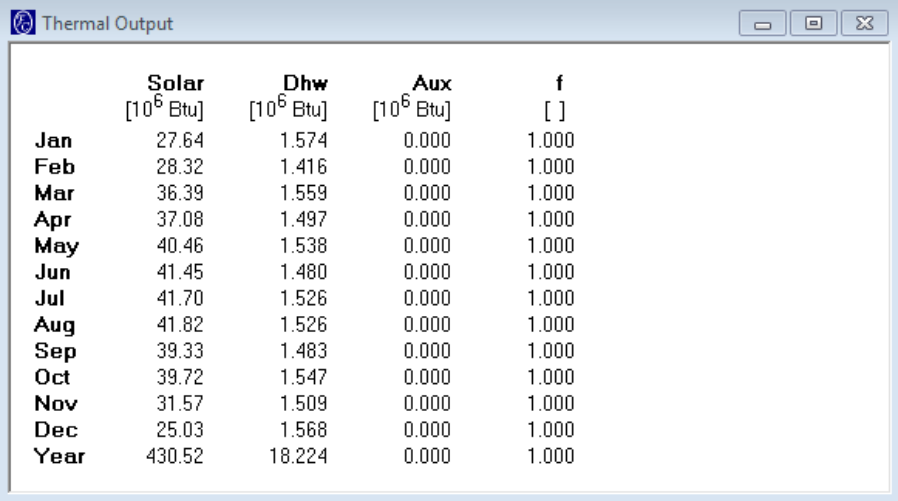


Figure 9-42 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	1.574	0.000	1.000
Feb	28.32	1.416	0.000	1.000
Mar	36.39	1.559	0.000	1.000
Apr	37.08	1.497	0.000	1.000
May	40.46	1.538	0.000	1.000
Jun	41.45	1.480	0.000	1.000
Jul	41.70	1.526	0.000	1.000
Aug	41.82	1.526	0.000	1.000
Sep	39.33	1.483	0.000	1.000
Oct	39.72	1.547	0.000	1.000
Nov	31.57	1.509	0.000	1.000
Dec	25.03	1.568	0.000	1.000
Year	430.52	18.224	0.000	1.000

Figure 9-43 F-Chart Simulation

9.6.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-44, Figure 9-45 and Figure 9-46.

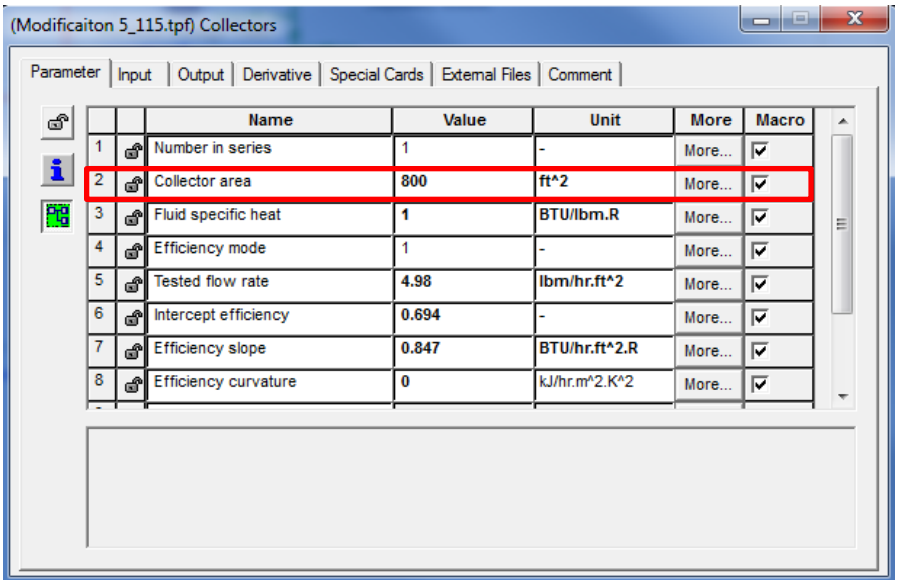


Figure 9-44 TRNSYS Component “Collectors” Settings

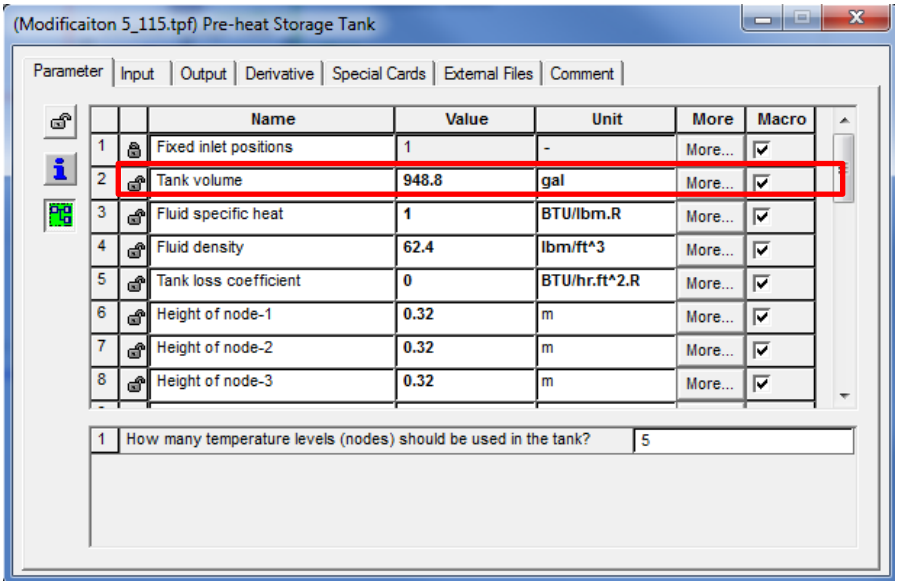


Figure 9-45 TRNSYS Component "Pre-heat Storage tank" Settings

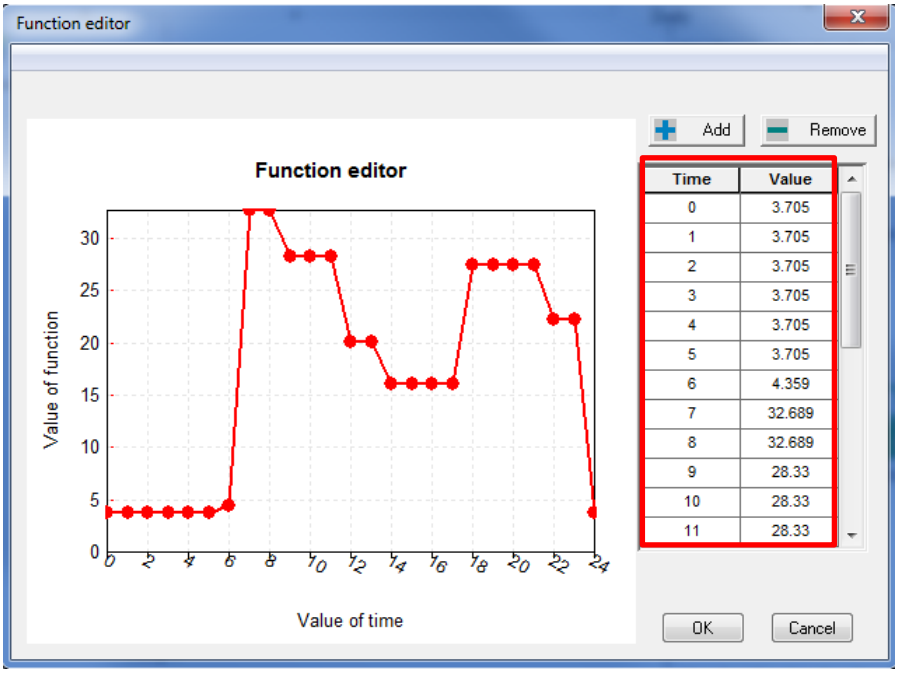


Figure 9-46 TRNSYS Component "Hot Water Demand" Settings

Figure 9-47 - Figure 9-50 present the simulation comparisons for ANALYSIS 5 (115 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-5, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

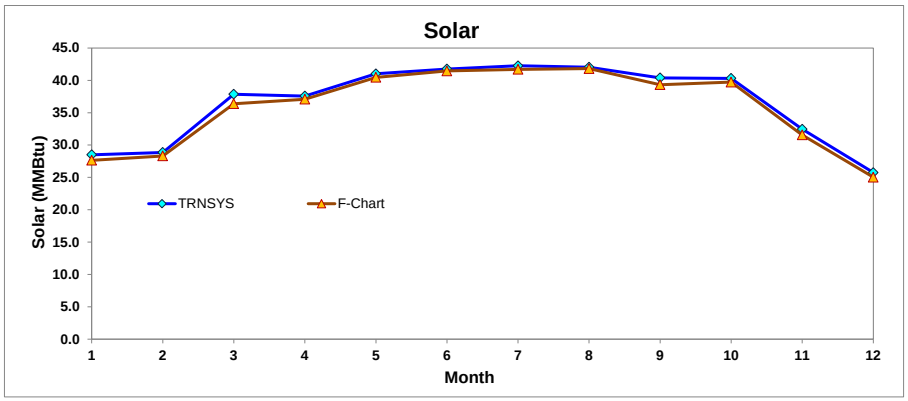


Figure 9-47 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (115 gallons/day)

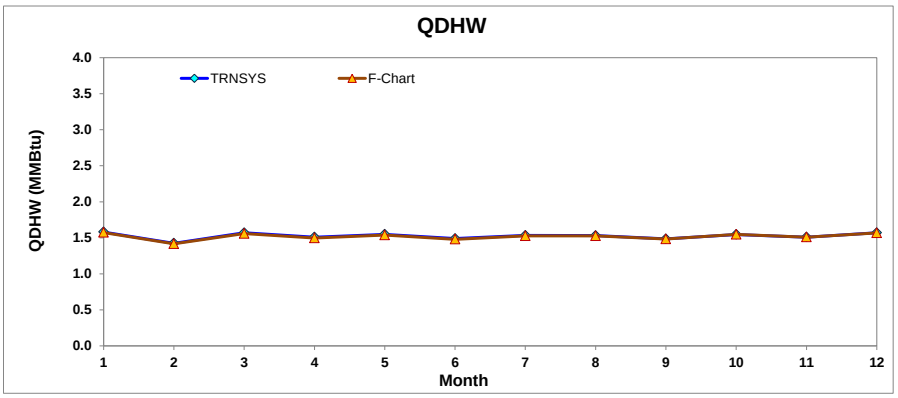


Figure 9-48Monthly Total Water Heating Demand -ANALYSIS 5 (115 gallons/day)

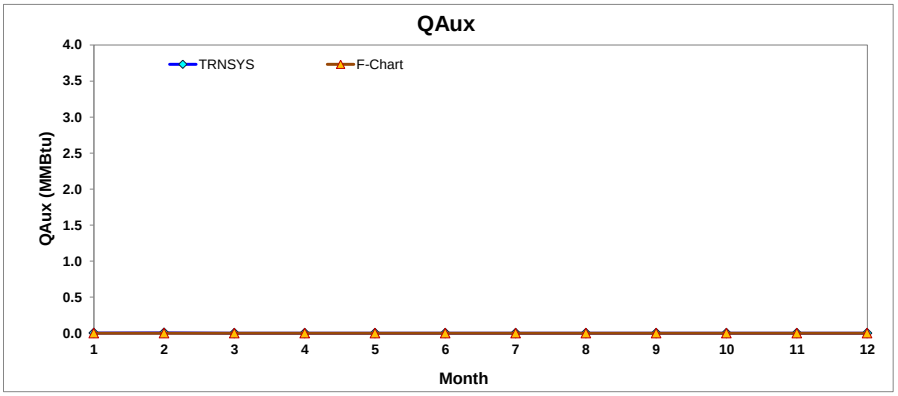


Figure 9-49Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (115 gallons/day)

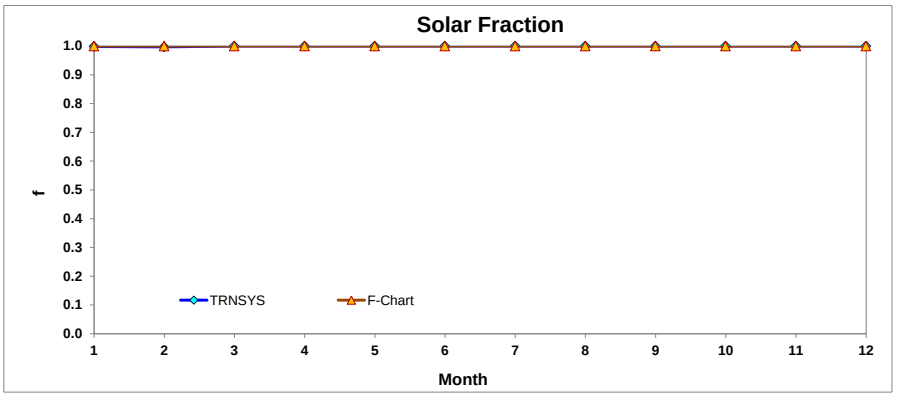


Figure 9-50Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (115 gallons/day)

Table 9-5 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (115 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	1.581	0.002	0.999	27.640	1.574	0.000	1.000	-3.1%	-0.4%	N/A	0.1%
Feb	28.856	1.424	0.004	0.997	28.320	1.416	0.000	1.000	-1.9%	0.6%	N/A	0.3%
Mar	37.856	1.569	0.000	1.000	36.390	1.559	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	37.573	1.509	0.000	1.000	37.080	1.497	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	41.013	1.549	0.000	1.000	40.460	1.538	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.751	1.490	0.000	1.000	41.450	1.480	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.258	1.534	0.000	1.000	41.700	1.526	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.033	1.531	0.000	1.000	41.820	1.526	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	40.389	1.486	0.000	1.000	39.330	1.483	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	40.300	1.546	0.000	1.000	39.720	1.547	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	32.452	1.509	0.000	1.000	31.570	1.509	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	25.754	1.569	0.000	1.000	25.030	1.568	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.730	18.296	0.006	1.000	430.520	18.224	0.000	1.000	-1.9%	0.4%	N/A	0.0%

9.7 Analysis 5-146 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 146 gallons/day with the storage tank volume 948.8 gallons.

9.7.1 F-Chart simulation

Figure 9-51 and Figure 9-52 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-53 gives the result summary of modified simulation.

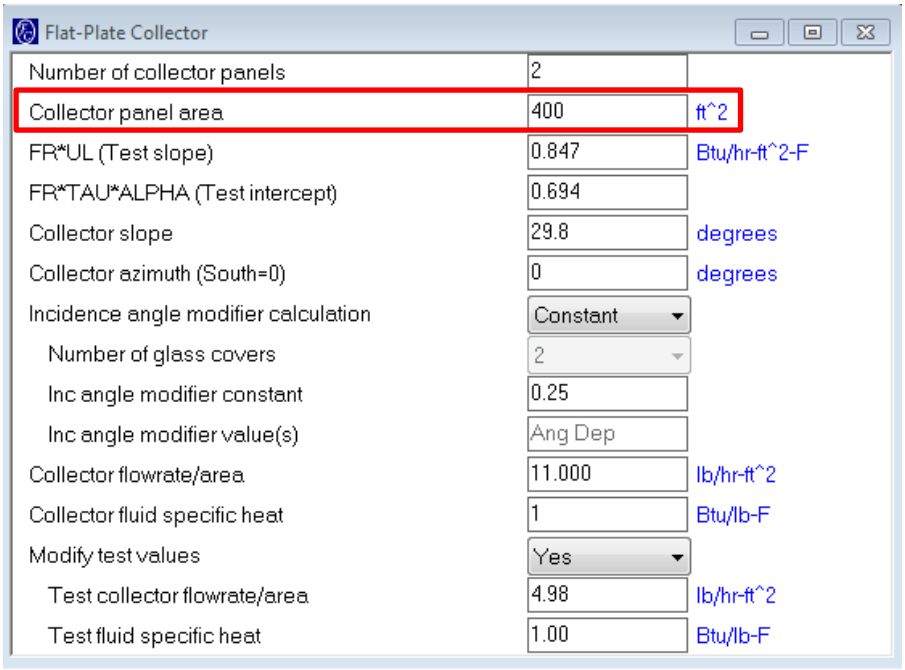


Figure 9-51 Flat-Plate Collector Input

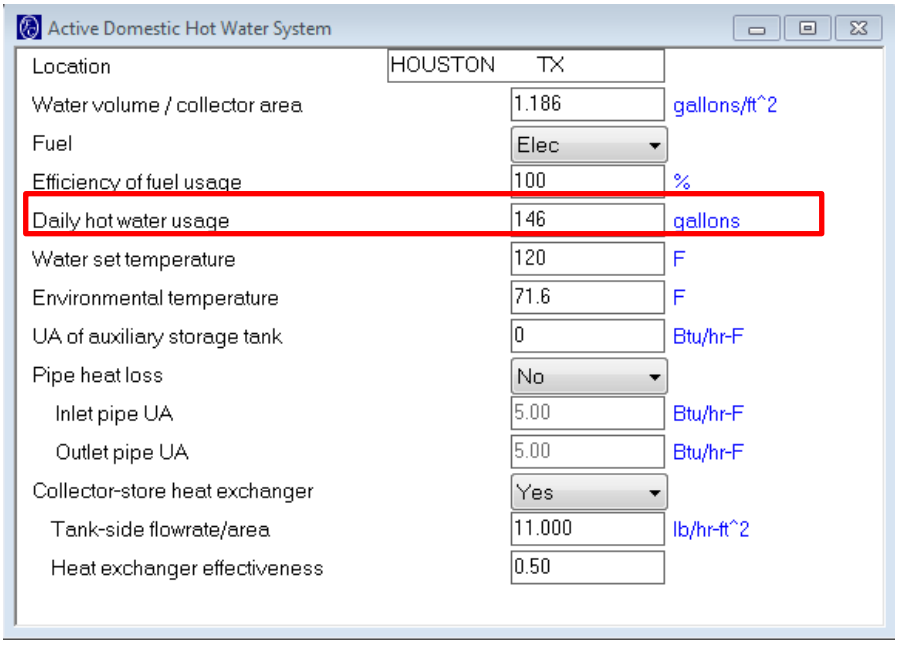
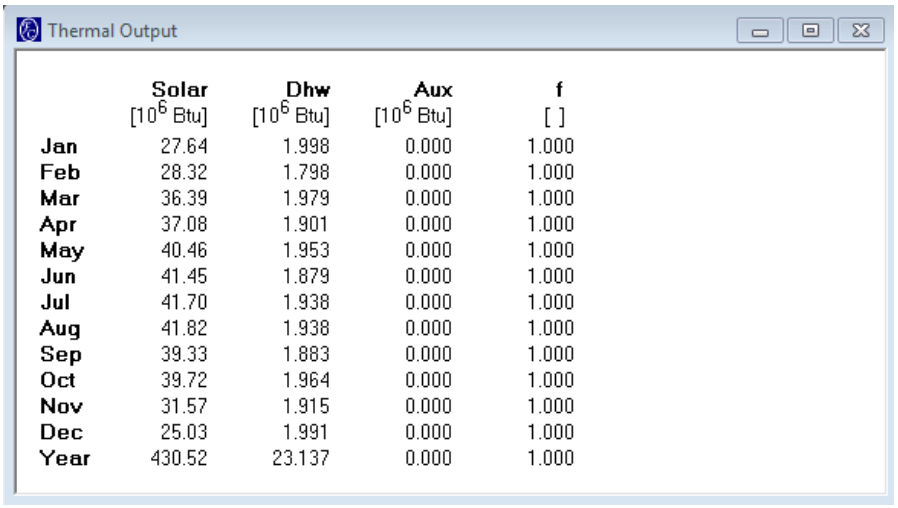


Figure 9-52 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	1.998	0.000	1.000
Feb	28.32	1.798	0.000	1.000
Mar	36.39	1.979	0.000	1.000
Apr	37.08	1.901	0.000	1.000
May	40.46	1.953	0.000	1.000
Jun	41.45	1.879	0.000	1.000
Jul	41.70	1.938	0.000	1.000
Aug	41.82	1.938	0.000	1.000
Sep	39.33	1.883	0.000	1.000
Oct	39.72	1.964	0.000	1.000
Nov	31.57	1.915	0.000	1.000
Dec	25.03	1.991	0.000	1.000
Year	430.52	23.137	0.000	1.000

Figure 9-53 F-Chart Simulation

9.7.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-54, Figure 9-55 and Figure 9-56.

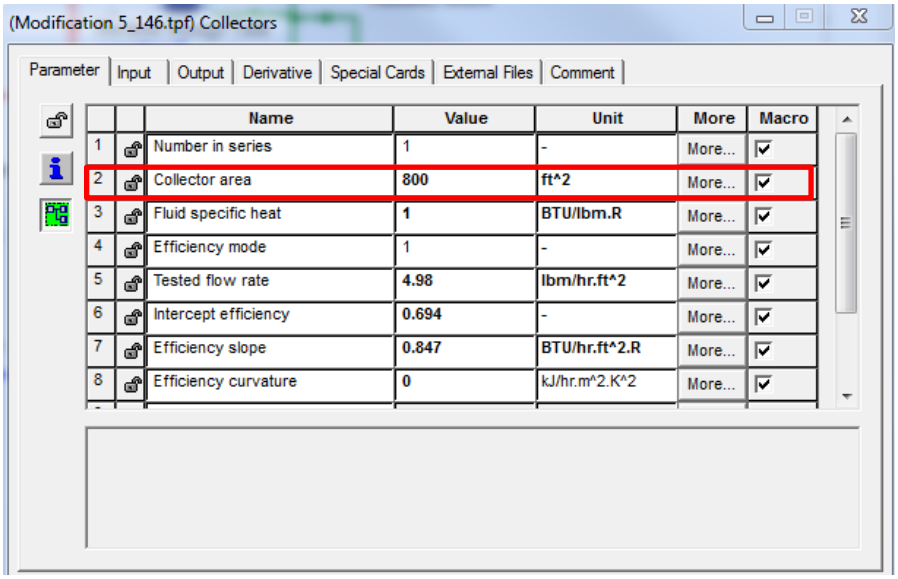


Figure 9-54 TRNSYS Component “Collectors” Settings

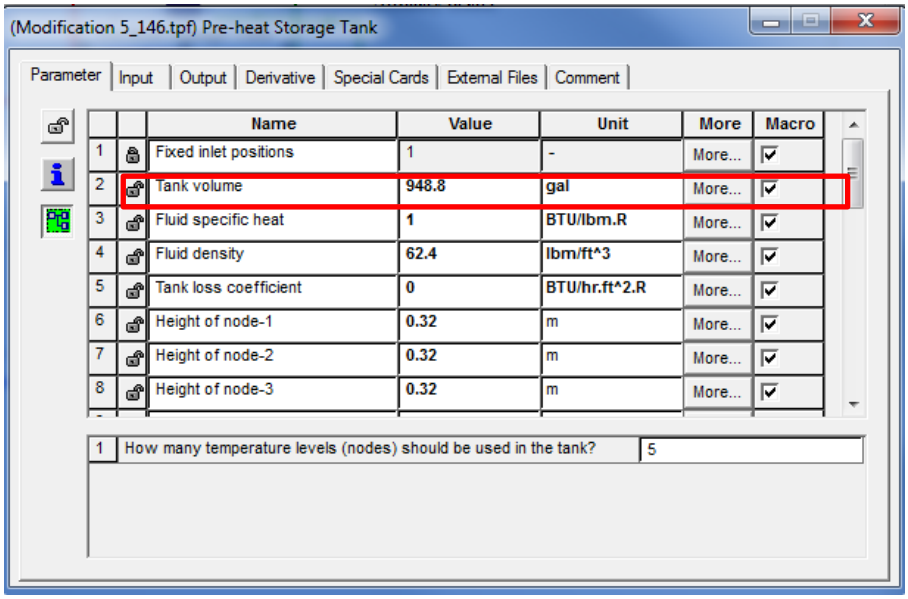


Figure 9-55 TRNSYS Component "Pre-heat Storage tank" Settings

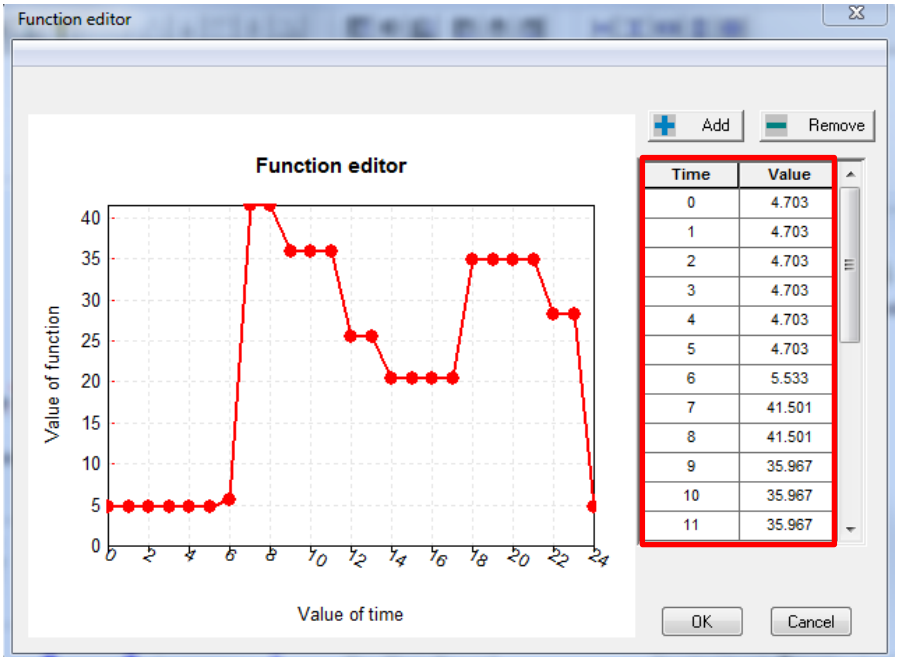


Figure 9-56 TRNSYS Component "Hot Water Demand" Settings

Figure 9-57 - Figure 9-60 present the simulation comparisons for ANALYSIS 5 (146 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-5, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0.3 %, respectively.

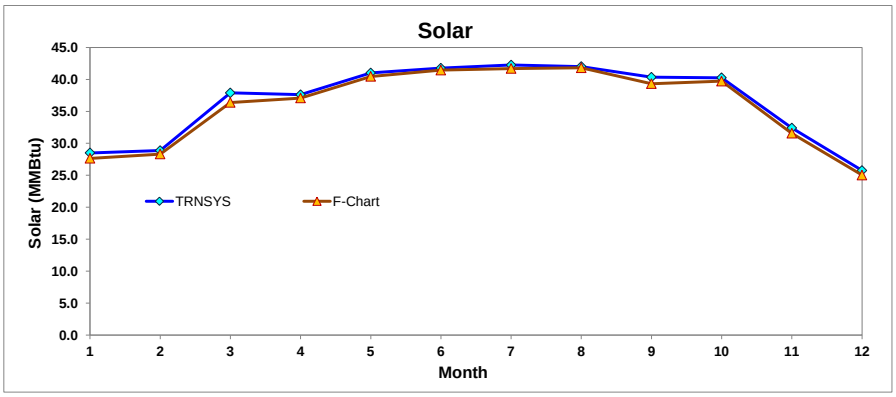


Figure 9-57 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (146 gallons/day)

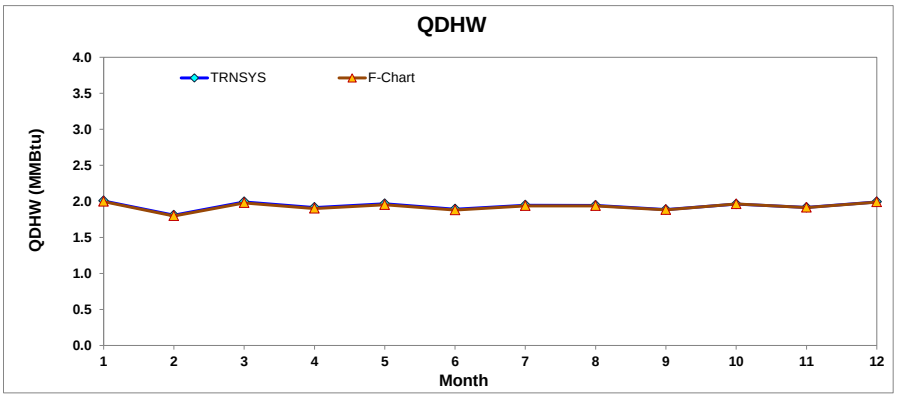


Figure 9-58Monthly Total Water Heating Demand -ANALYSIS 5 (146 gallons/day)

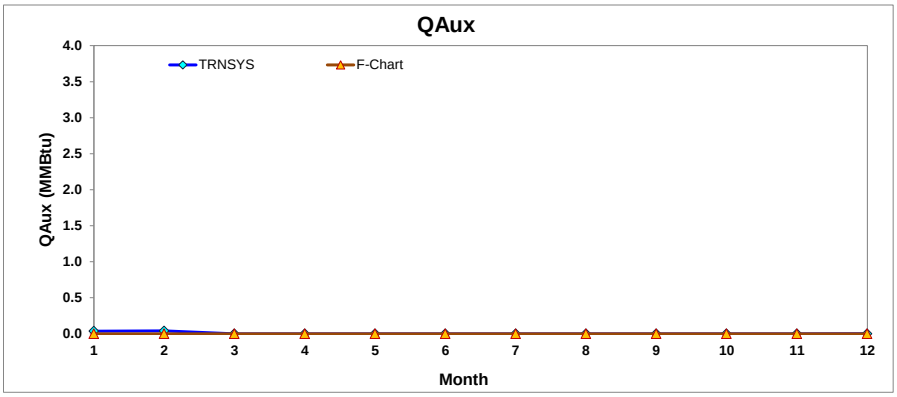


Figure 9-59Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (146 gallons/day)

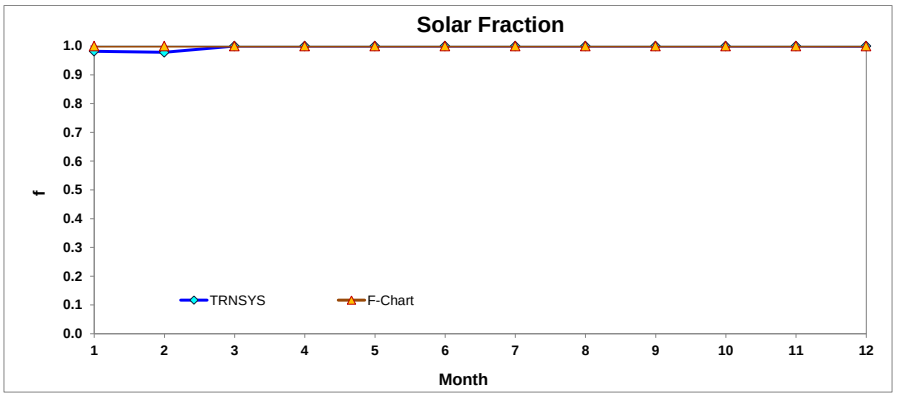


Figure 9-60Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (146 gallons/day)

Table 9-6 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (146 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	2.007	0.036	0.982	27.640	1.998	0.000	1.000	-3.1%	-0.4%	N/A	1.8%
Feb	28.877	1.808	0.039	0.978	28.320	1.798	0.000	1.000	-2.0%	0.6%	N/A	2.2%
Mar	37.892	1.993	0.000	1.000	36.390	1.979	0.000	1.000	-4.1%	0.7%	N/A	0.0%
Apr	37.615	1.915	0.000	1.000	37.080	1.901	0.000	1.000	-1.4%	0.8%	N/A	0.0%
May	41.013	1.966	0.000	1.000	40.460	1.953	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.758	1.892	0.000	1.000	41.450	1.879	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.251	1.947	0.000	1.000	41.700	1.938	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.004	1.945	0.000	1.000	41.820	1.938	0.000	1.000	-0.4%	0.4%	N/A	0.0%
Sep	40.347	1.886	0.000	1.000	39.330	1.883	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	40.251	1.962	0.000	1.000	39.720	1.964	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	32.409	1.916	0.000	1.000	31.570	1.915	0.000	1.000	-2.7%	0.0%	N/A	0.0%
Dec	25.746	1.993	0.000	1.000	25.030	1.991	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.659	23.230	0.076	0.997	430.520	23.137	0.000	1.000	-1.9%	0.4%	N/A	0.3%

9.8 Analysis 5-147 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 147 gallons/day with the storage tank volume 948.8 gallons.

9.8.1 F-Chart simulation

Figure 9-61 and Figure 9-62 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-63 gives the result summary of modified simulation.

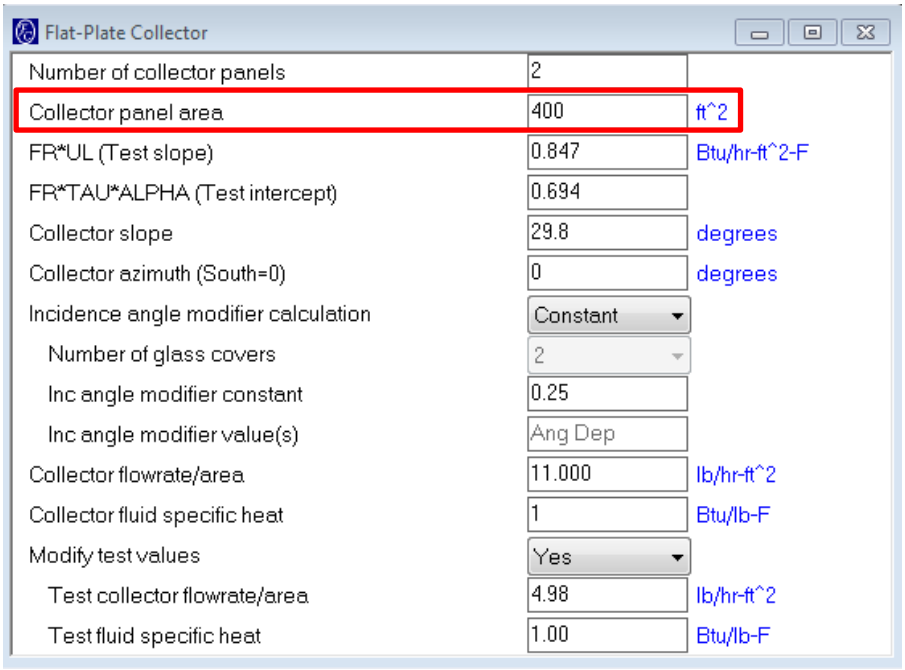


Figure 9-61 Flat-Plate Collector Input

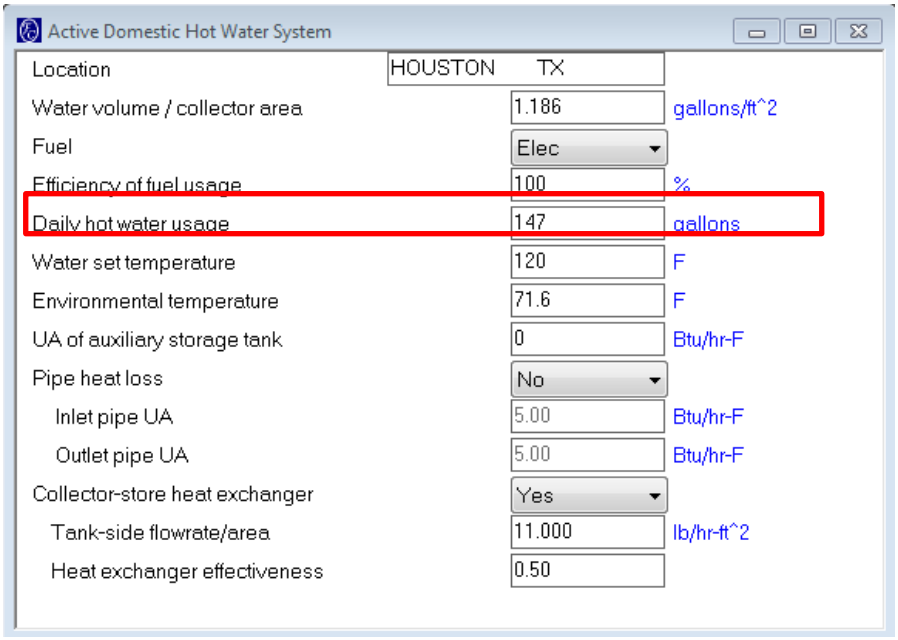
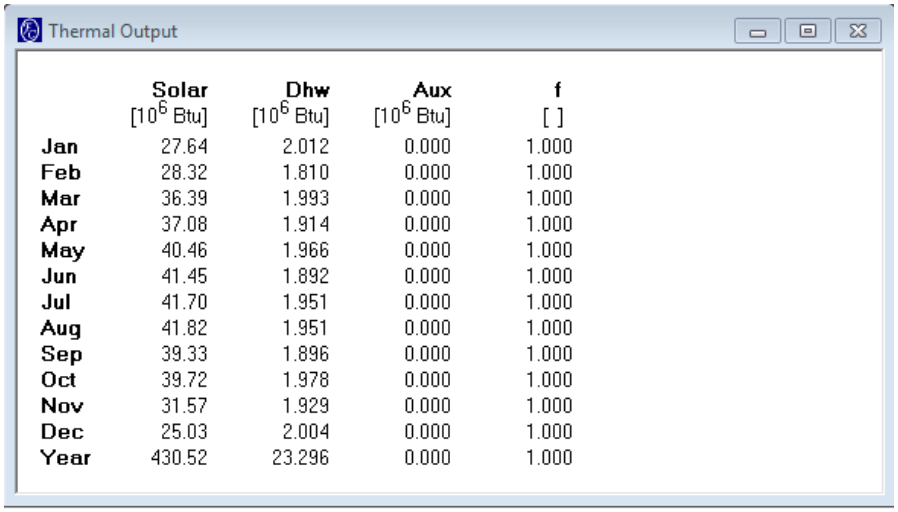


Figure 9-62 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	2.012	0.000	1.000
Feb	28.32	1.810	0.000	1.000
Mar	36.39	1.993	0.000	1.000
Apr	37.08	1.914	0.000	1.000
May	40.46	1.966	0.000	1.000
Jun	41.45	1.892	0.000	1.000
Jul	41.70	1.951	0.000	1.000
Aug	41.82	1.951	0.000	1.000
Sep	39.33	1.896	0.000	1.000
Oct	39.72	1.978	0.000	1.000
Nov	31.57	1.929	0.000	1.000
Dec	25.03	2.004	0.000	1.000
Year	430.52	23.296	0.000	1.000

Figure 9-63 F-Chart Simulation

9.8.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-64, Figure 9-65 and Figure 9-66.

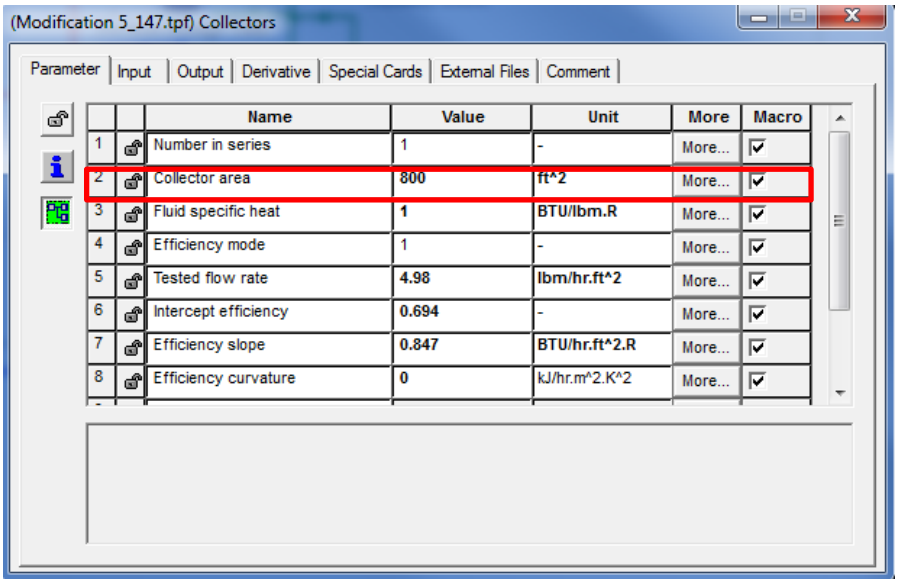


Figure 9-64 TRNSYS Component “Collectors” Settings

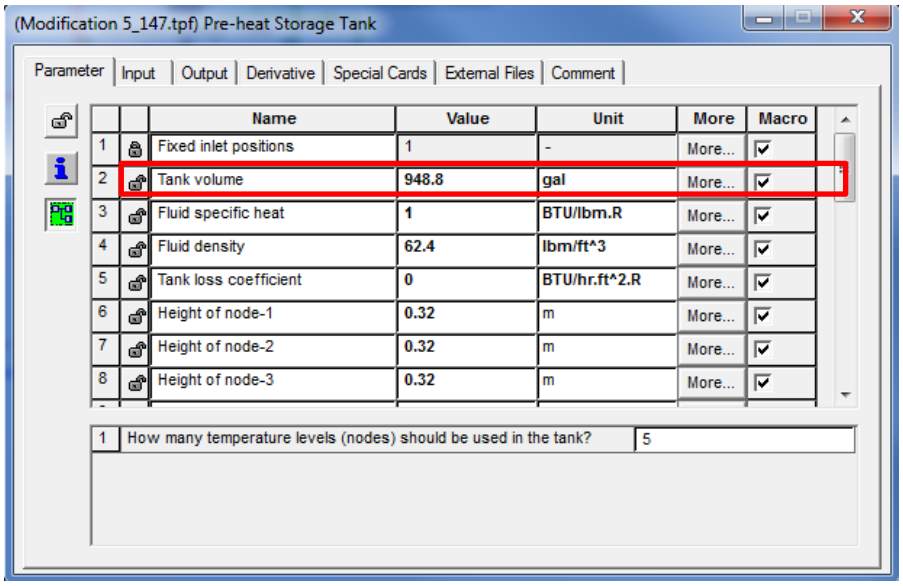


Figure 9-65 TRNSYS Component "Pre-heat Storage tank" Settings

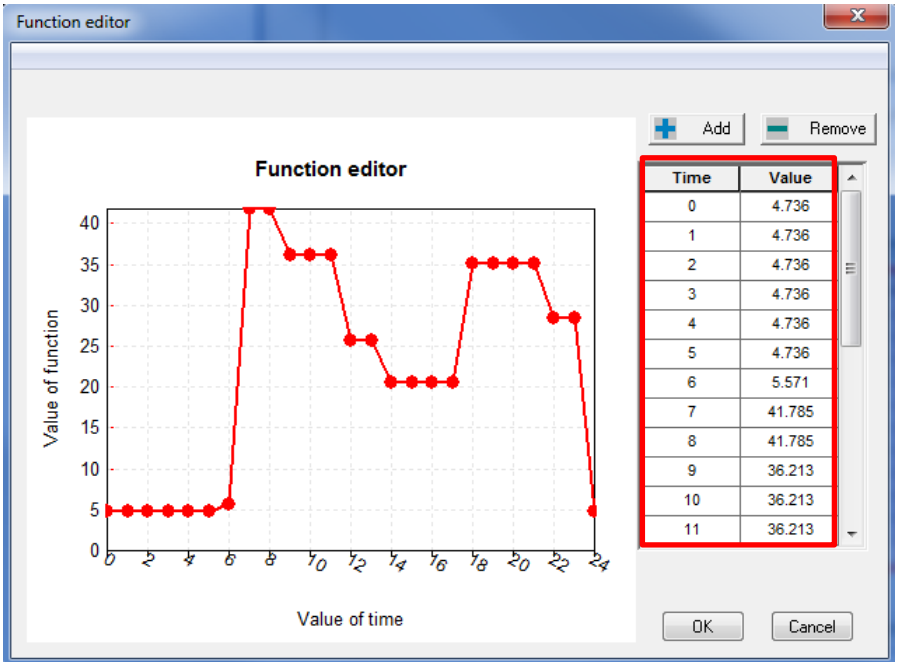


Figure 9-66 TRNSYS Component "Hot Water Demand" Settings

Figure 9-67 - Figure 9-70 present the simulation comparisons for ANALYSIS 5 (147 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-7, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0.3 %, respectively.

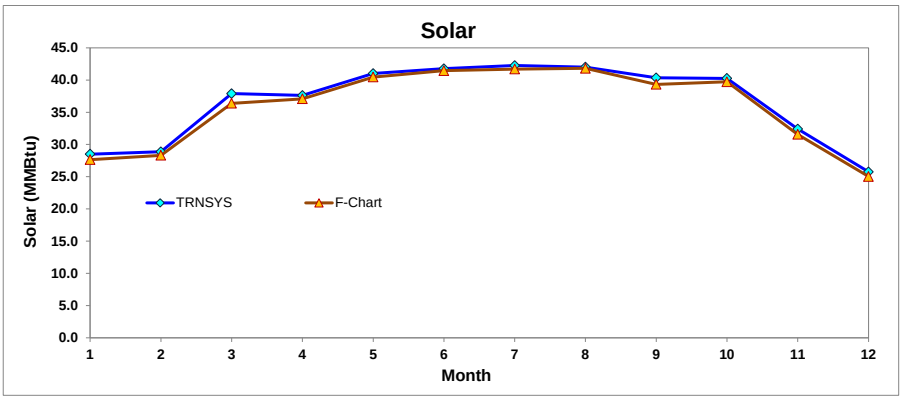


Figure 9-67 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (147 gallons/day)

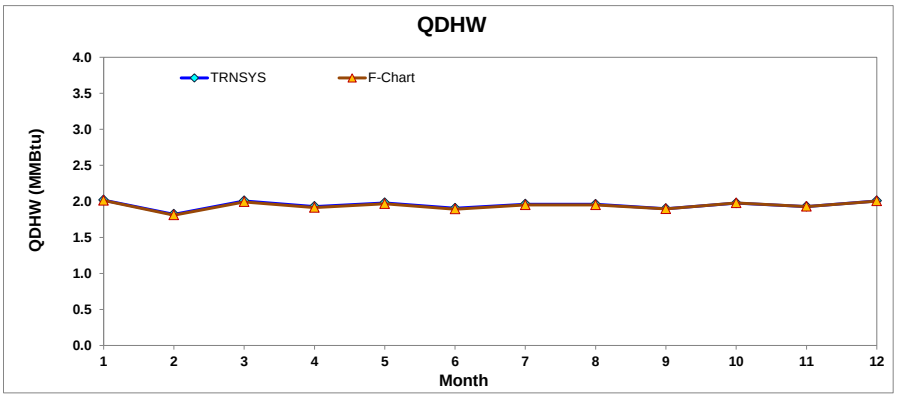


Figure 9-68Monthly Total Water Heating Demand -ANALYSIS 5 (147 gallons/day)

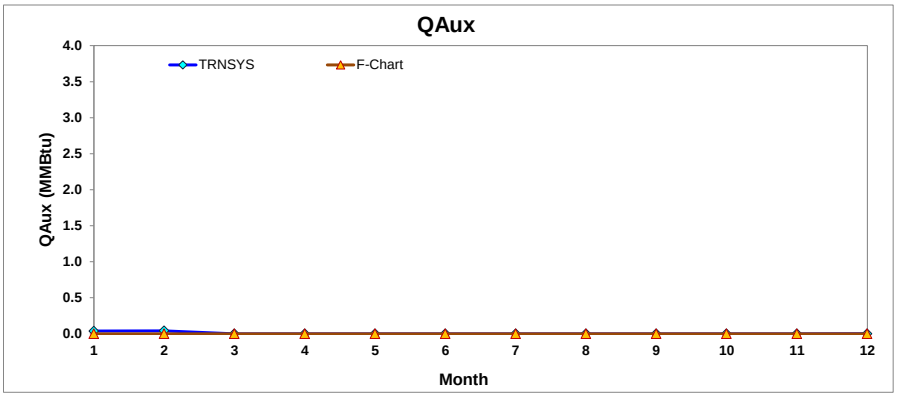


Figure 9-69Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (147 gallons/day)

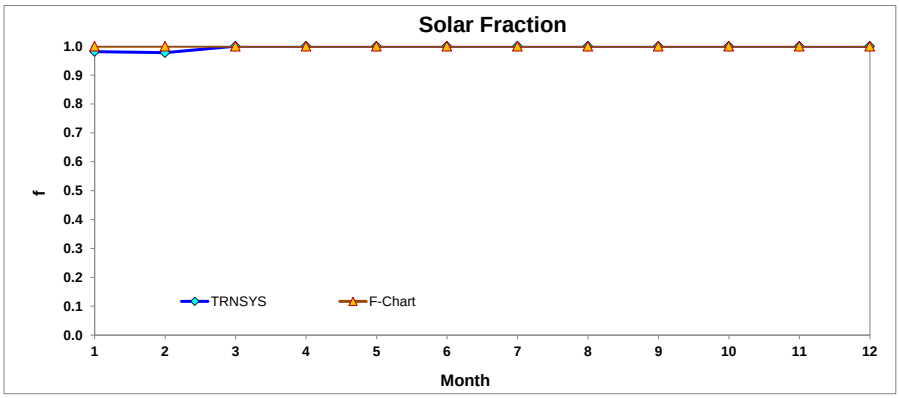


Figure 9-70Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (147 gallons/day)

Table 9-7 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (147 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	2.019	0.037	0.981	27.640	2.012	0.000	1.000	-3.1%	-0.3%	N/A	1.9%
Feb	28.877	1.821	0.041	0.978	28.320	1.810	0.000	1.000	-2.0%	0.6%	N/A	2.2%
Mar	37.892	2.006	0.000	1.000	36.390	1.993	0.000	1.000	-4.1%	0.7%	N/A	0.0%
Apr	37.615	1.929	0.000	1.000	37.080	1.914	0.000	1.000	-1.4%	0.8%	N/A	0.0%
May	41.013	1.979	0.000	1.000	40.460	1.966	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.758	1.905	0.000	1.000	41.450	1.892	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.251	1.961	0.000	1.000	41.700	1.951	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.004	1.960	0.000	1.000	41.820	1.951	0.000	1.000	-0.4%	0.5%	N/A	0.0%
Sep	40.347	1.899	0.000	1.000	39.330	1.896	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	40.251	1.976	0.000	1.000	39.720	1.978	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	32.409	1.929	0.000	1.000	31.570	1.929	0.000	1.000	-2.7%	0.0%	N/A	0.0%
Dec	25.746	2.006	0.001	1.000	25.030	2.004	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	438.659	23.389	0.079	0.997	430.520	23.296	0.000	1.000	-1.9%	0.4%	N/A	0.3%

9.9 Analysis 5-150 Gallons/Day

The total collector area is 800 ft^2 and daily hot water usage is 150 gallons/day with the storage tank volume 948.8 gallons.

9.9.1 F-Chart simulation

Figure 9-71 and Figure 9-72 show the input information for F-Chart. The changed settings are presented in a red box. Figure 9-73 gives the result summary of modified simulation.

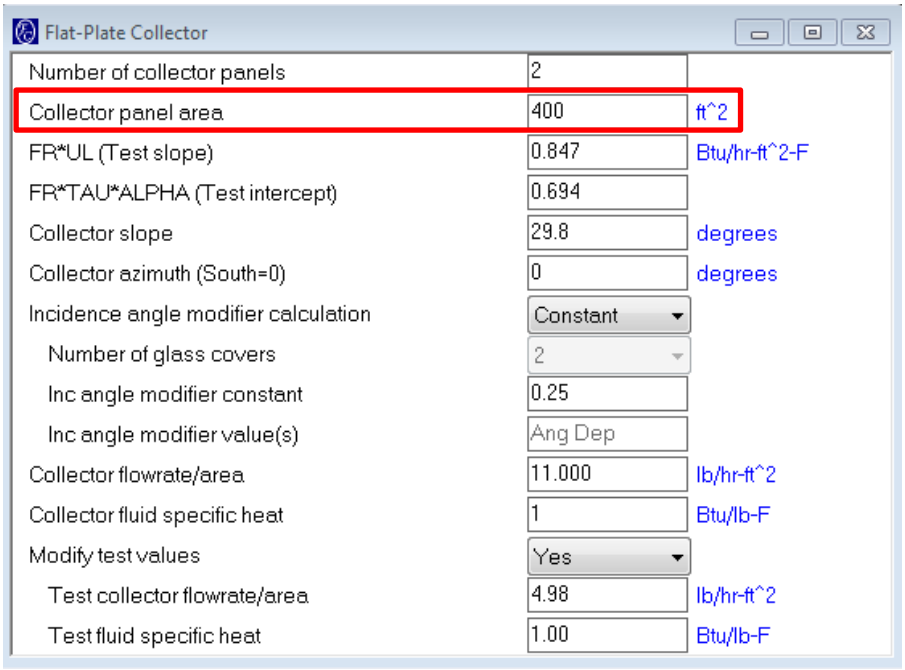


Figure 9-71 Flat-Plate Collector Input

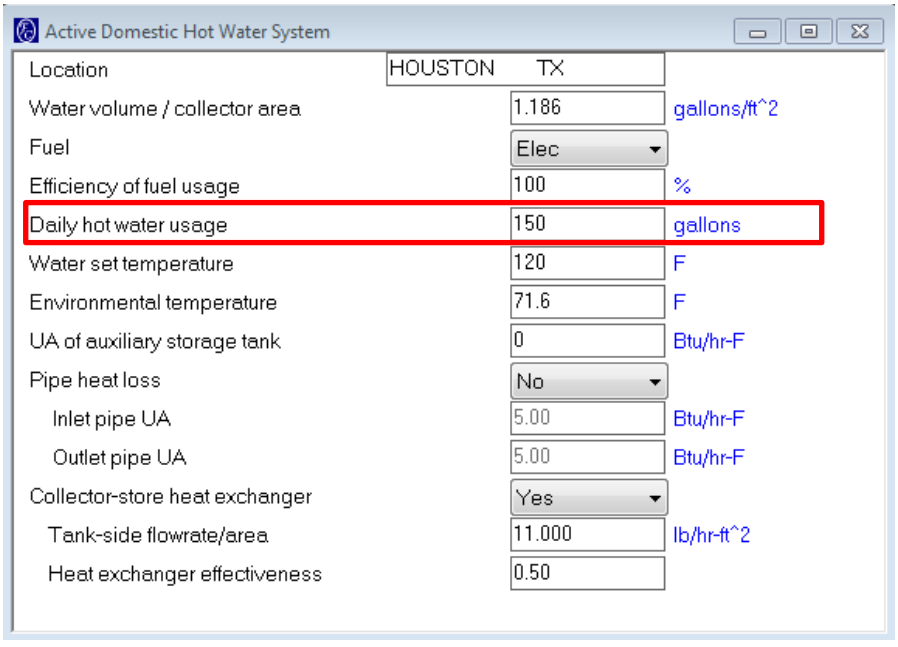
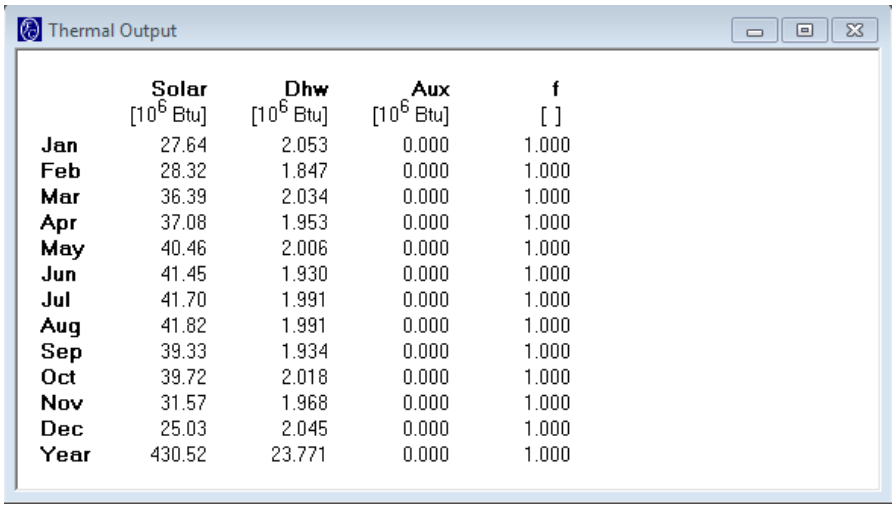


Figure 9-72 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	27.64	2.053	0.000	1.000
Feb	28.32	1.847	0.000	1.000
Mar	36.39	2.034	0.000	1.000
Apr	37.08	1.953	0.000	1.000
May	40.46	2.006	0.000	1.000
Jun	41.45	1.930	0.000	1.000
Jul	41.70	1.991	0.000	1.000
Aug	41.82	1.991	0.000	1.000
Sep	39.33	1.934	0.000	1.000
Oct	39.72	2.018	0.000	1.000
Nov	31.57	1.968	0.000	1.000
Dec	25.03	2.045	0.000	1.000
Year	430.52	23.771	0.000	1.000

Figure 9-73 F-Chart Simulation

9.9.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 9-74, Figure 9-75 and Figure 9-76.

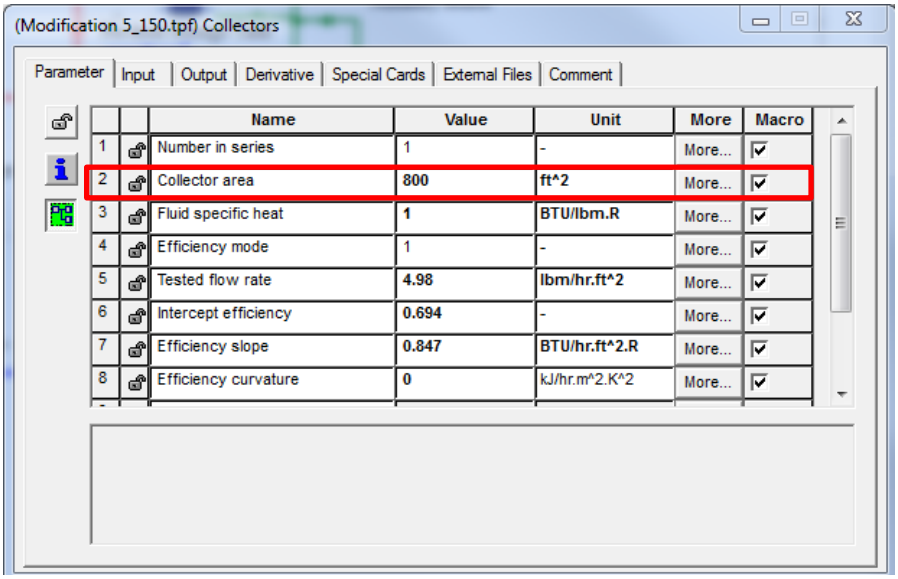


Figure 9-74 TRNSYS Component “Collectors” Settings

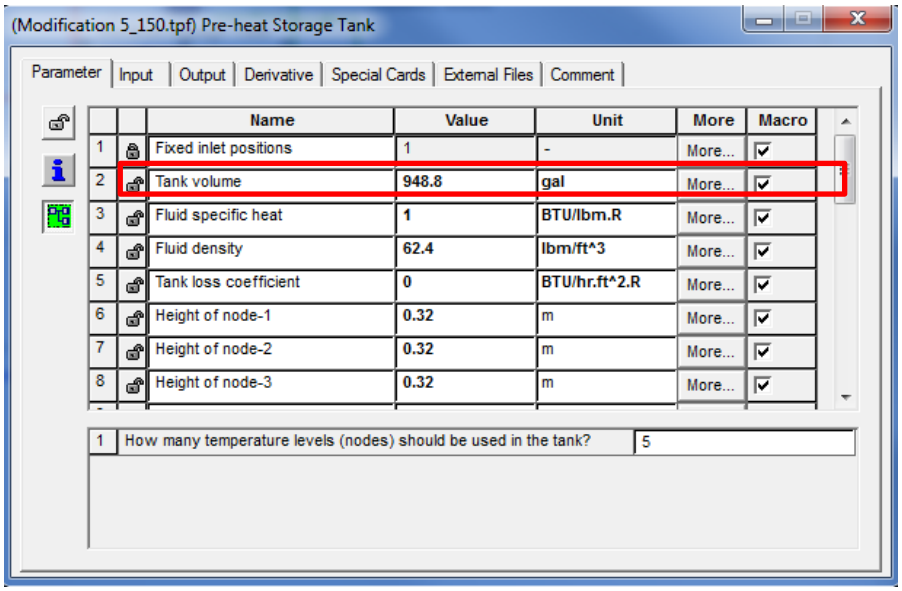


Figure 9-75 TRNSYS Component "Pre-heat Storage tank" Settings

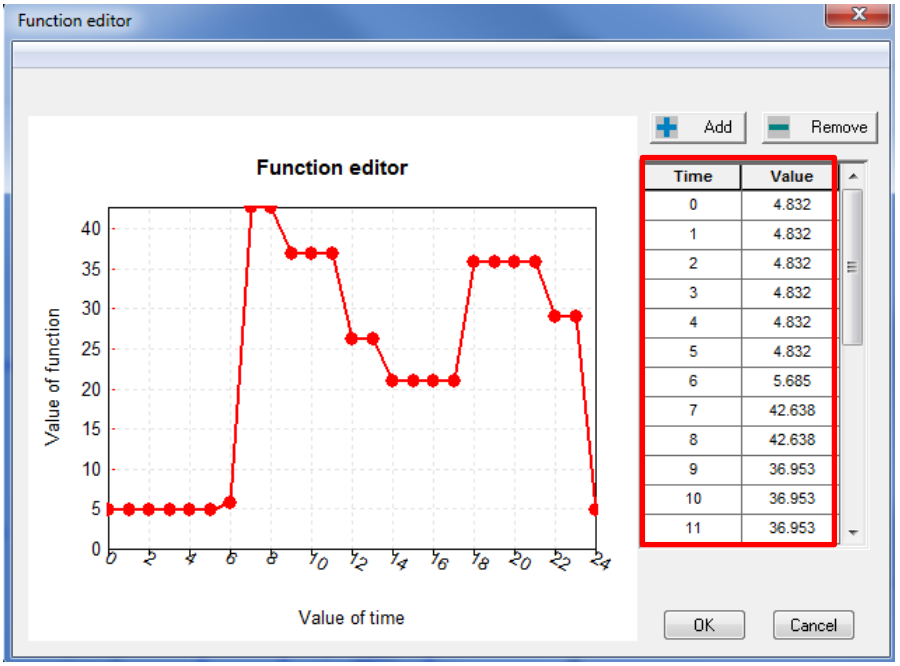


Figure 9-76 TRNSYS Component "Hot Water Demand" Settings

Figure 9-77 - Figure 9-80 present the simulation comparisons for ANALYSIS 5 (147 gallons/day) including Solar, Dhw, Aux and f factor. In Table 9-8, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0.4 %, respectively.

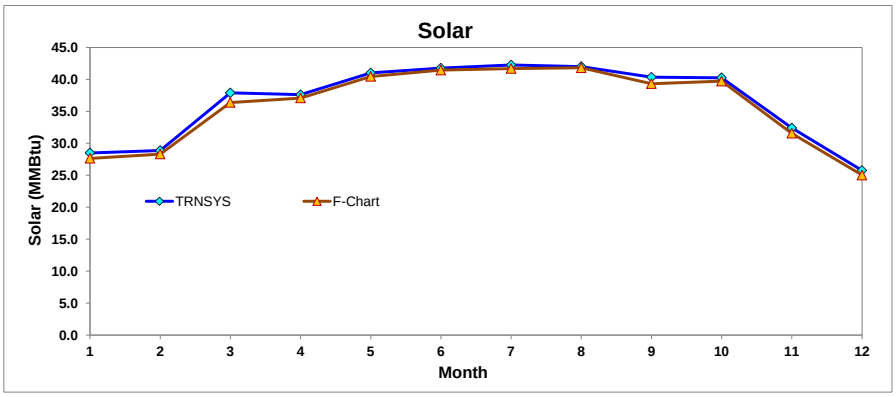


Figure 9-77 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 5 (150 gallons/day)

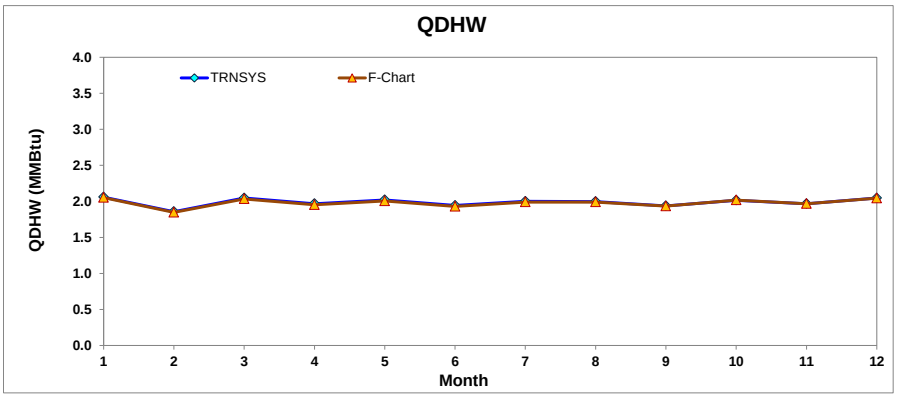


Figure 9-78Monthly Total Water Heating Demand -ANALYSIS 5 (150 gallons/day)

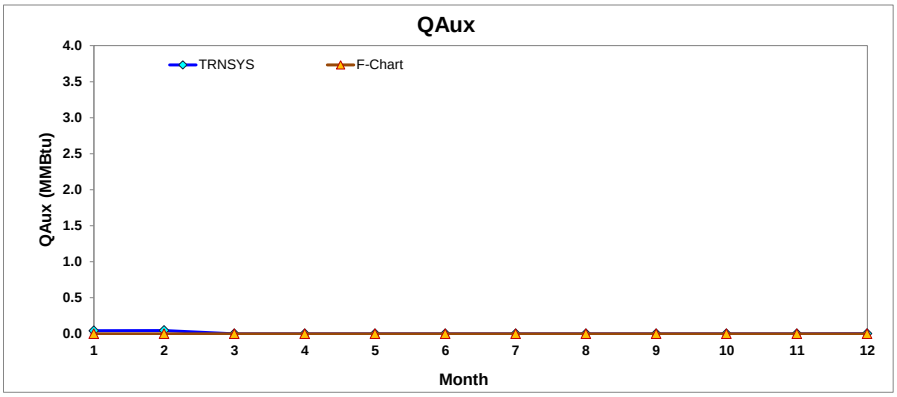


Figure 9-79Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 5 (150 gallons/day)

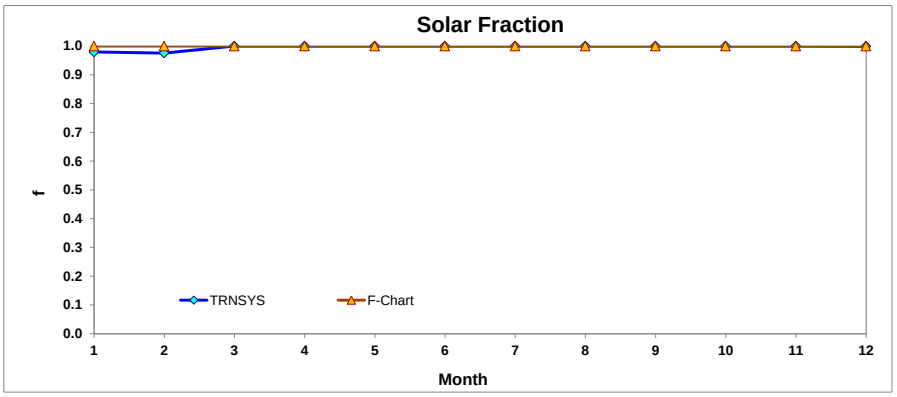


Figure 9-80Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 5 (150 gallons/day)

Table 9-8 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (150 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	28.496	2.060	0.042	0.979	27.640	2.053	0.000	1.000	-3.1%	-0.3%	N/A	2.1%
Feb	28.877	1.858	0.045	0.976	28.320	1.847	0.000	1.000	-2.0%	0.6%	N/A	2.4%
Mar	37.892	2.047	0.000	1.000	36.390	2.034	0.000	1.000	-4.1%	0.6%	N/A	0.0%
Apr	37.615	1.968	0.000	1.000	37.080	1.953	0.000	1.000	-1.4%	0.8%	N/A	0.0%
May	41.013	2.020	0.000	1.000	40.460	2.006	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	41.758	1.943	0.000	1.000	41.450	1.930	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	42.251	2.000	0.000	1.000	41.700	1.991	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	42.004	1.998	0.000	1.000	41.820	1.991	0.000	1.000	-0.4%	0.4%	N/A	0.0%
Sep	40.347	1.938	0.000	1.000	39.330	1.934	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	40.251	2.016	0.000	1.000	39.720	2.018	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	32.409	1.968	0.000	1.000	31.570	1.968	0.000	1.000	-2.7%	0.0%	N/A	0.0%
Dec	25.746	2.047	0.001	0.999	25.030	2.045	0.000	1.000	-2.9%	0.1%	N/A	0.1%
Year	438.659	23.864	0.089	0.996	430.520	23.771	0.000	1.000	-1.9%	0.4%	N/A	0.4%

9.10 Discussion

Figure 9-81 compares the f factor of SDHW system simulated by TRNSYS and F-Chart. It has shown that both results follow the same pattern and trend. As the daily hot water usage increases, the f factor equals to 1 or approximately 1. For daily hot water usage equals to 146,147 and 150 gallons/day, the f factor by TRNSYS simulation cannot achieve 1 because the storage tank volume is too large to fulfill the hot water demand only by solar collectors.

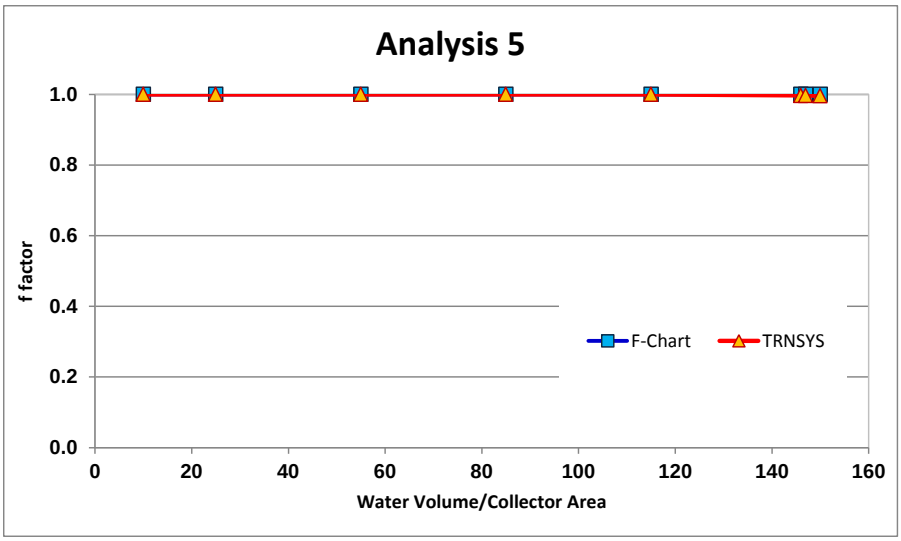


Figure 9-81 f Factor Comparisons between F-Chart and TRNSYS – ANALYSIS 5

10 SOLAR DOMESTIC HOT WATER SYSTEM SIMULATION COMPARISONS OF ANALYSIS 6 - DAILY HOT WATER USAGE STUDY PART III

10.1 Overview

Starting from this section, different case studies are performed to further checking the simulation accuracy of TRNSYS program on SDHW System. This section will vary the total collector area from 64.02 ft^2 to 8000 ft^2. With 8000ft^2 total solar collector area, the daily hot water usage is varied by 10,25,55,85,115, 461 and 462 gallons/day. The other settings are kept as the same as base case.

10.2 Analysis 6-10 Gallons/Day

The total collector area is 8000 ft^2 and daily hot water usage is 10 gallons/day with the storage tank volume 9488 gallons.

10.2.1 F-Chart simulation

Figure 10-1 and Figure 10-2 show the input information for F-Chart. The changed settings are presented in a red box. Figure 10-3 gives the result summary of modified simulation.

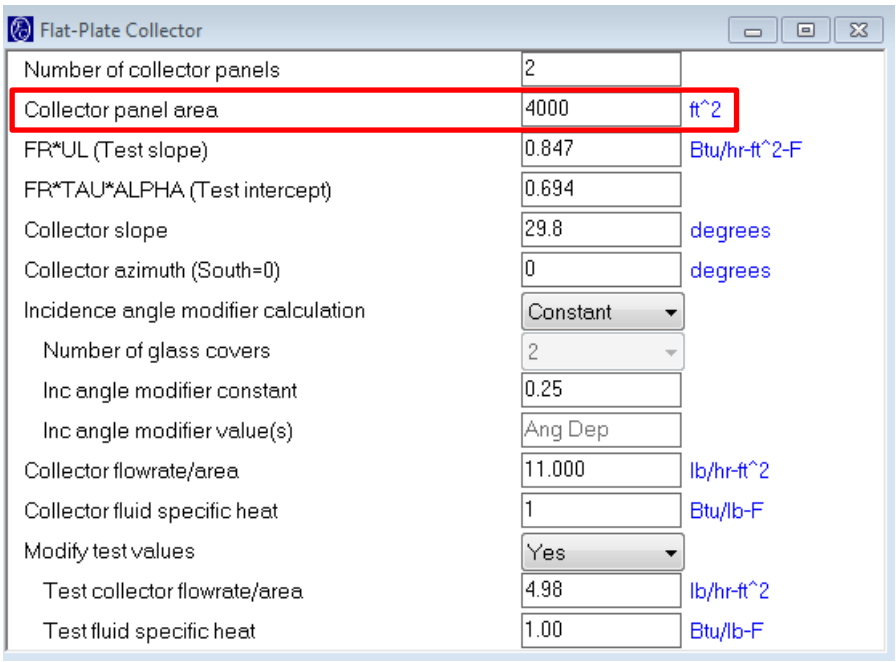


Figure 10-1 Flat-Plate Collector Input

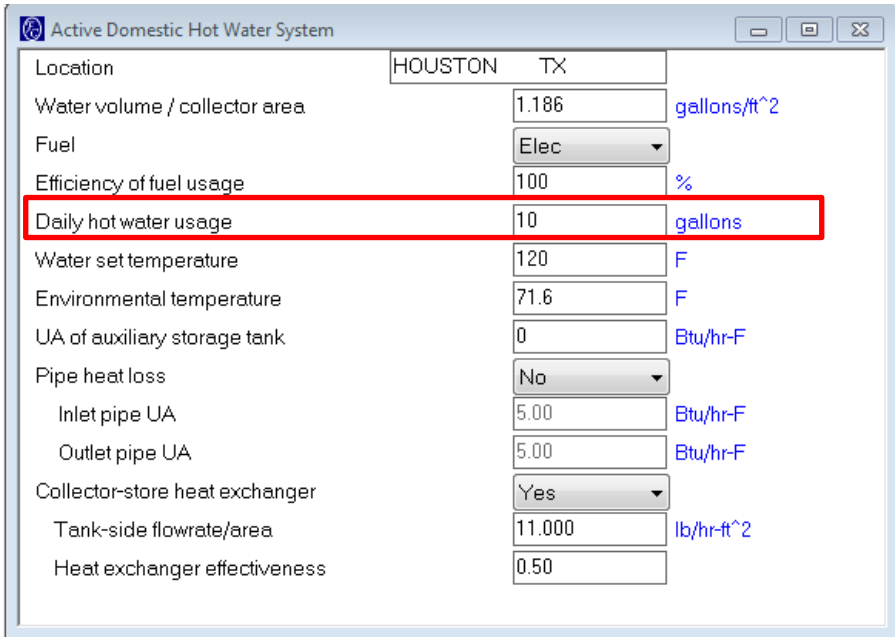
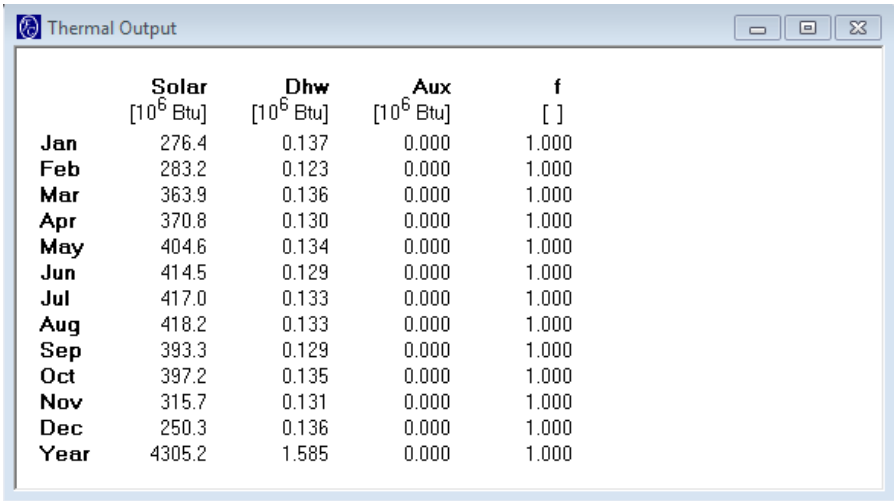


Figure 10-2 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	0.137	0.000	1.000
Feb	283.2	0.123	0.000	1.000
Mar	363.9	0.136	0.000	1.000
Apr	370.8	0.130	0.000	1.000
May	404.6	0.134	0.000	1.000
Jun	414.5	0.129	0.000	1.000
Jul	417.0	0.133	0.000	1.000
Aug	418.2	0.133	0.000	1.000
Sep	393.3	0.129	0.000	1.000
Oct	397.2	0.135	0.000	1.000
Nov	315.7	0.131	0.000	1.000
Dec	250.3	0.136	0.000	1.000
Year	4305.2	1.585	0.000	1.000

Figure 10-3 F-Chart Simulation

10.2.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 10-4, Figure 10-5 and Figure 10-6.

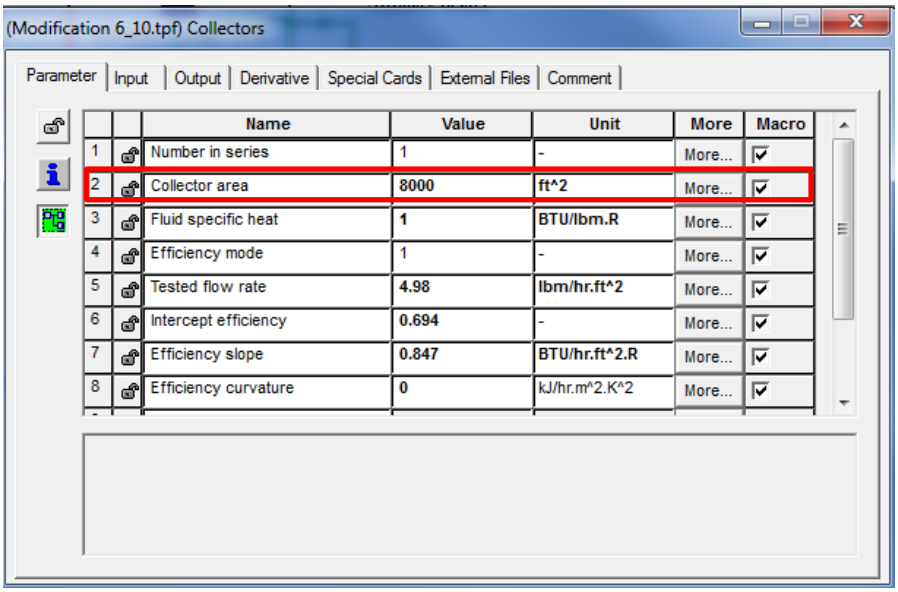


Figure 10-4 TRNSYS Component “Collectors” Settings

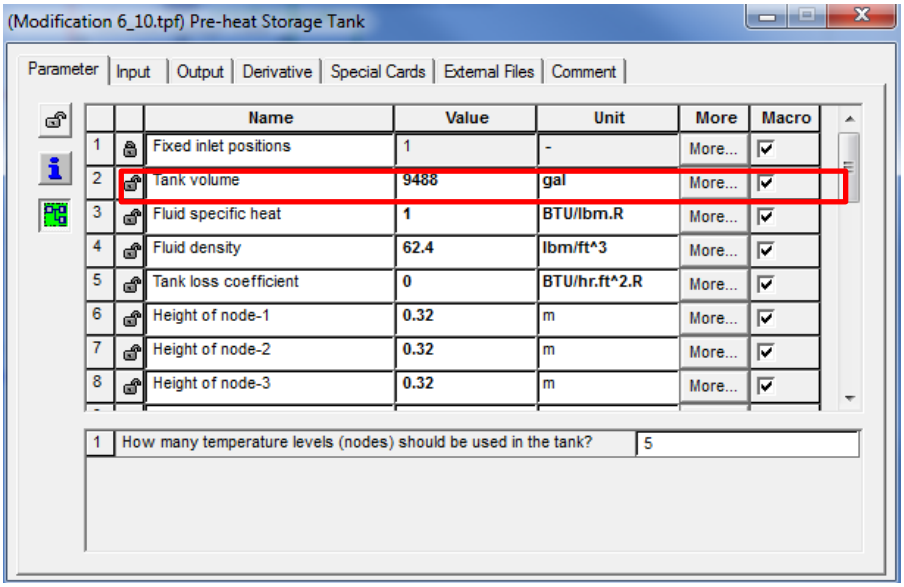


Figure 10-5 TRNSYS Component "Pre-heat Storage tank" Settings

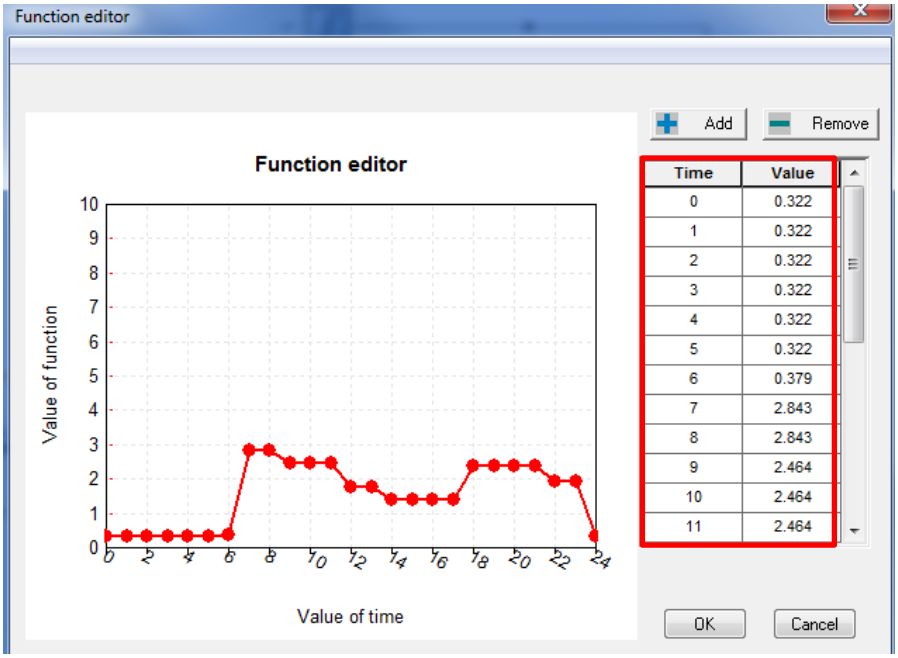


Figure 10-6 TRNSYS Component "Hot Water Demand" Settings

Figure 10-7 - Figure 10-10 present the simulation comparisons for ANALYSIS 6 (10 gallons/day) including Solar, Dhw, Aux and f factor. In Table 10-1, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

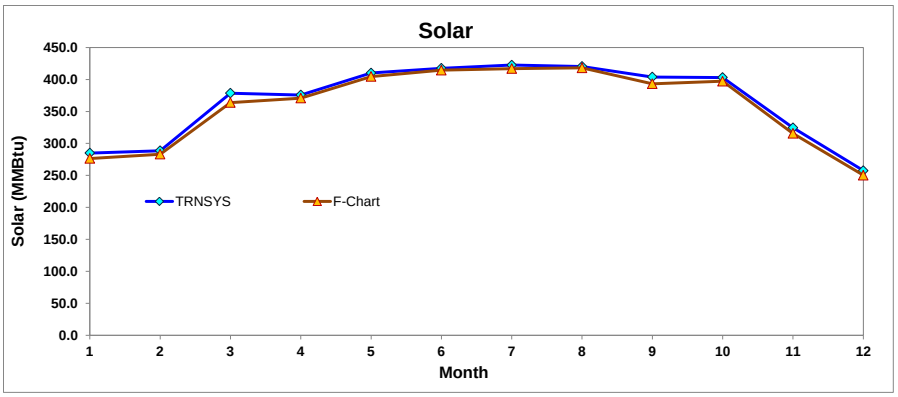


Figure 10-7 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 6 (10 gallons/day)

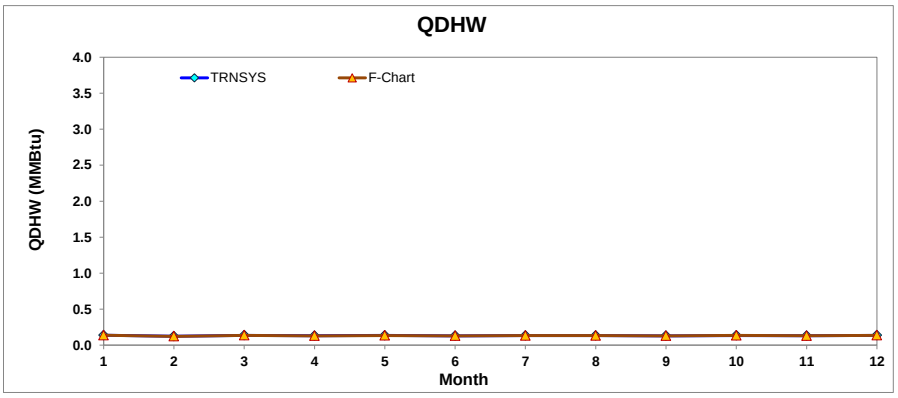


Figure 10-8Monthly Total Water Heating Demand -ANALYSIS 6 (10 gallons/day)

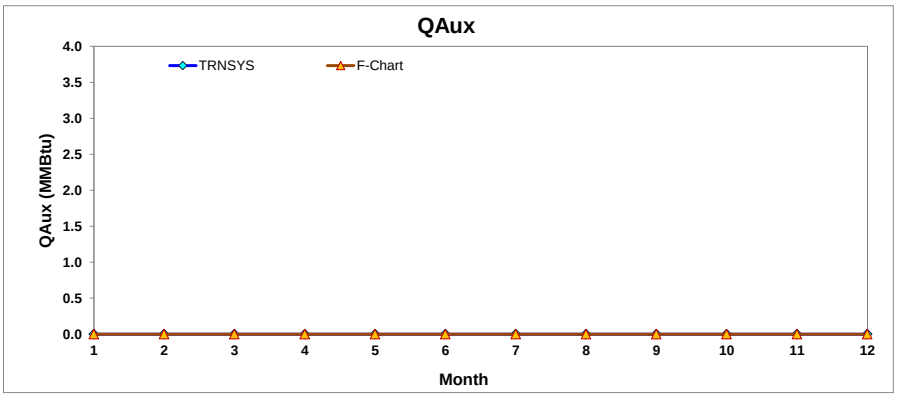


Figure 10-9Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 6 (10 gallons/day)

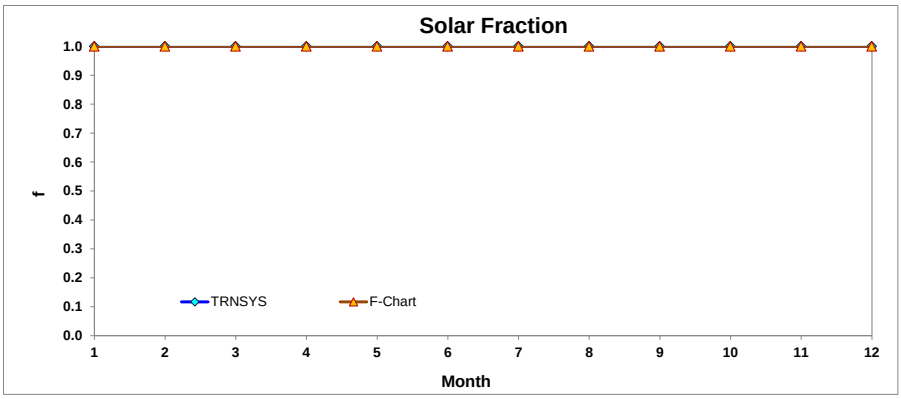


Figure 10-10Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 6 (10 gallons/day)

Table 10-1 Comparisons Data between TRNSYS and F-Chart ANALYSIS 6 (10 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	0.138	0.000	1.000	276.400	0.137	0.000	1.000	-3.1%	-0.4%	N/A	0.0%
Feb	288.558	0.124	0.000	1.000	283.200	0.123	0.000	1.000	-1.9%	0.7%	N/A	0.0%
Mar	378.561	0.136	0.000	1.000	363.900	0.136	0.000	1.000	-4.0%	0.4%	N/A	0.0%
Apr	375.729	0.131	0.000	1.000	370.800	0.130	0.000	1.000	-1.3%	0.9%	N/A	0.0%
May	410.133	0.135	0.000	1.000	404.600	0.134	0.000	1.000	-1.4%	0.5%	N/A	0.0%
Jun	417.508	0.130	0.000	1.000	414.500	0.129	0.000	1.000	-0.7%	0.4%	N/A	0.0%
Jul	422.580	0.133	0.000	1.000	417.000	0.133	0.000	1.000	-1.3%	0.3%	N/A	0.0%
Aug	420.326	0.133	0.000	1.000	418.200	0.133	0.000	1.000	-0.5%	0.1%	N/A	0.0%
Sep	403.892	0.129	0.000	1.000	393.300	0.129	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	403.004	0.134	0.000	1.000	397.200	0.135	0.000	1.000	-1.5%	0.4%	N/A	0.0%
Nov	324.518	0.131	0.000	1.000	315.700	0.131	0.000	1.000	-2.8%	0.2%	N/A	0.0%
Dec	257.535	0.136	0.000	1.000	250.300	0.136	0.000	1.000	-2.9%	0.4%	N/A	0.0%
Year	4387.304	1.591	0.000	1.000	4305.200	1.585	0.000	1.000	-1.9%	0.4%	N/A	0.0%

10.3 Analysis 6-25 Gallons/Day

The total collector area is 8000 ft^2 and daily hot water usage is 25 gallons/day with the storage tank volume 9488 gallons.

10.3.1 F-Chart simulation

Figure 10-11 and Figure 10-12 show the input information for F-Chart. The changed settings are presented in a red box. Figure 10-13 gives the result summary of modified simulation.

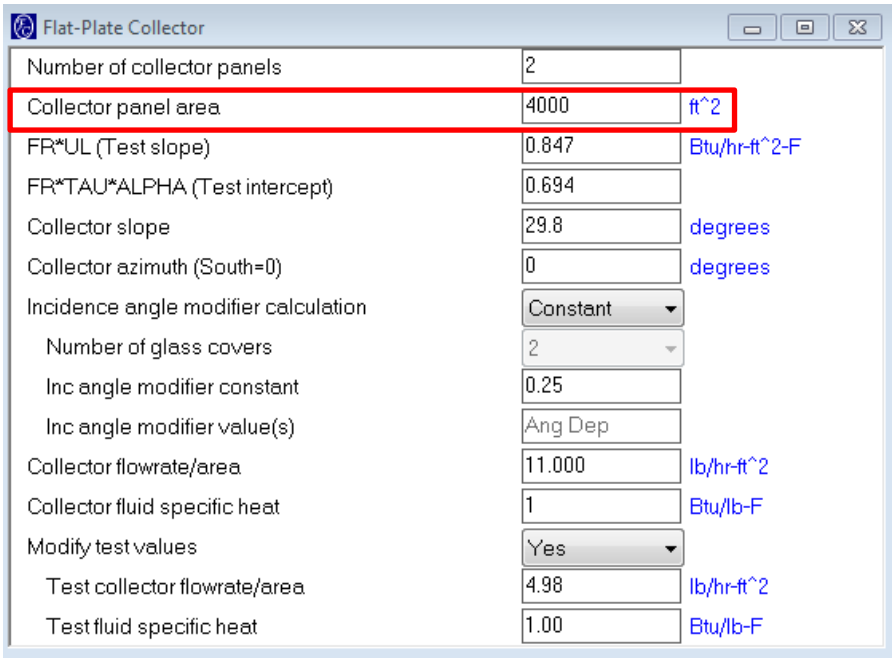


Figure 10-11 Flat-Plate Collector Input

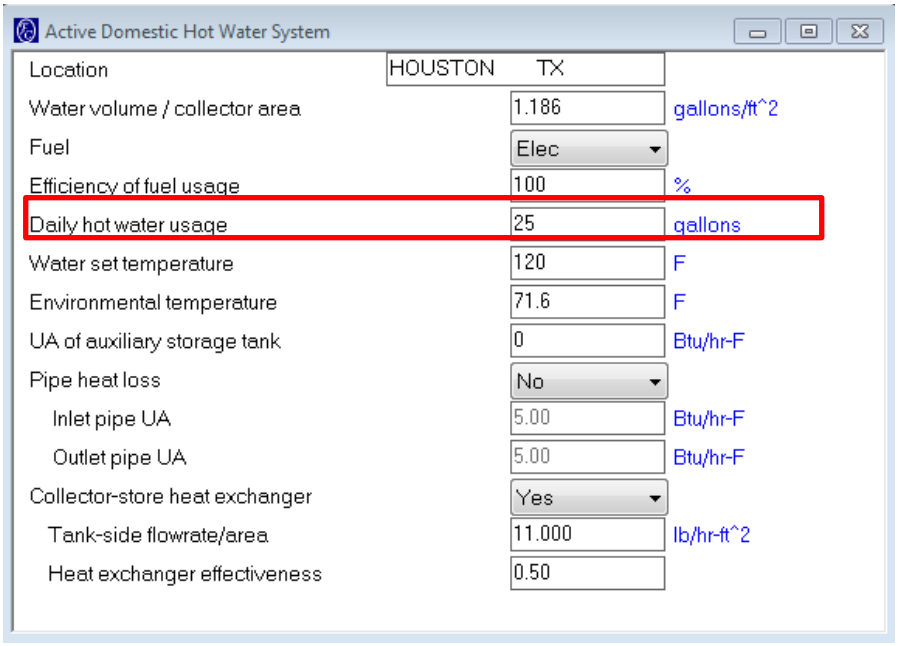
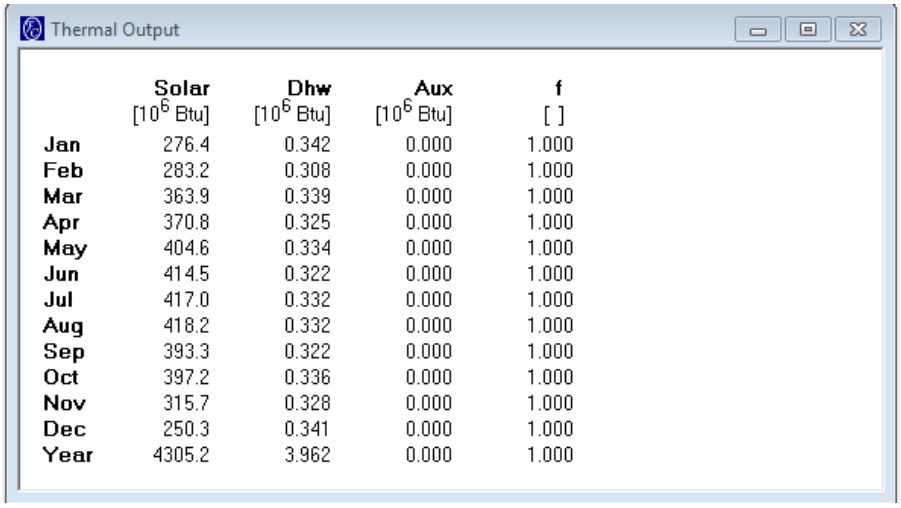


Figure 10-12 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	0.342	0.000	1.000
Feb	283.2	0.308	0.000	1.000
Mar	363.9	0.339	0.000	1.000
Apr	370.8	0.325	0.000	1.000
May	404.6	0.334	0.000	1.000
Jun	414.5	0.322	0.000	1.000
Jul	417.0	0.332	0.000	1.000
Aug	418.2	0.332	0.000	1.000
Sep	393.3	0.322	0.000	1.000
Oct	397.2	0.336	0.000	1.000
Nov	315.7	0.328	0.000	1.000
Dec	250.3	0.341	0.000	1.000
Year	4305.2	3.962	0.000	1.000

Figure 10-13 F-Chart Simulation

10.3.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 10-14, Figure 10-15 and Figure 10-16.

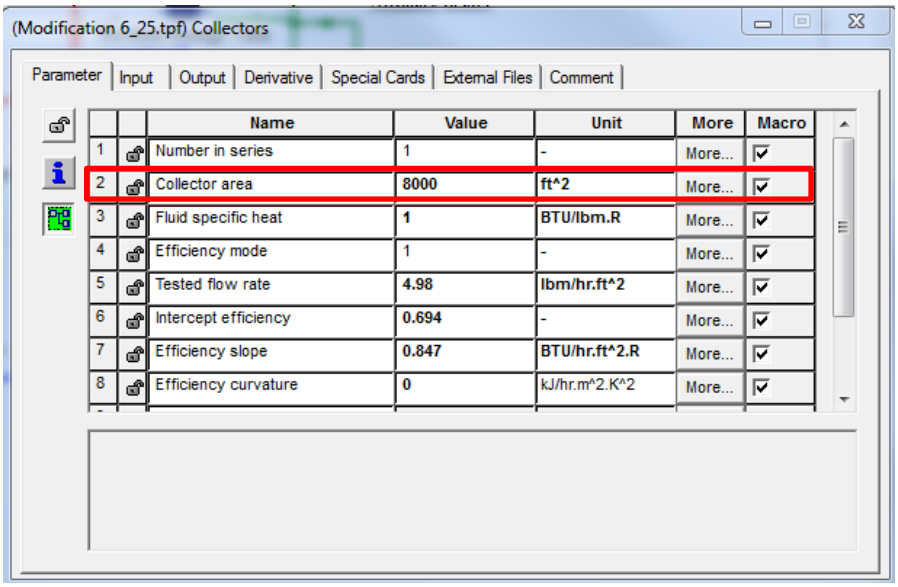


Figure 10-14 TRNSYS Component “Collectors” Settings

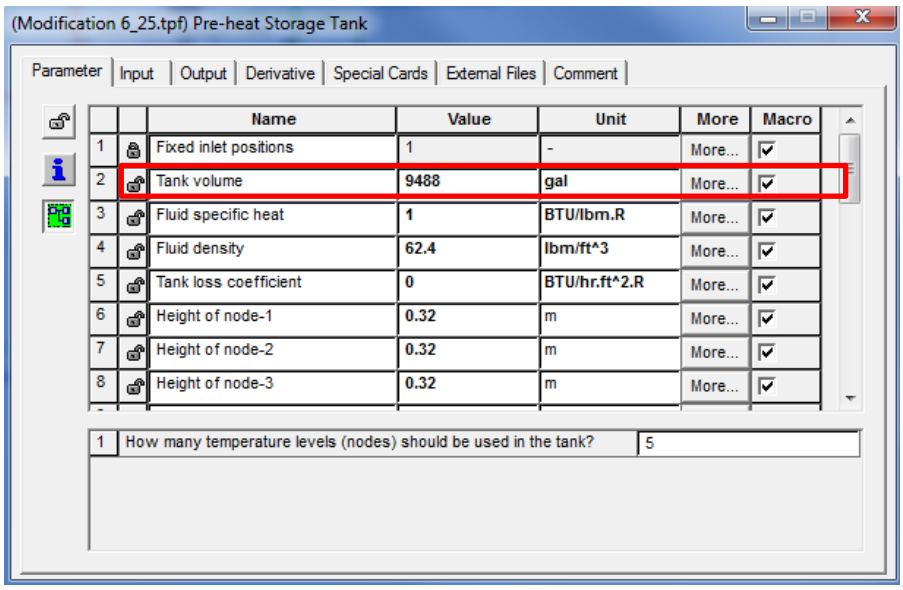


Figure 10-15 TRNSYS Component "Pre-heat Storage tank" Settings

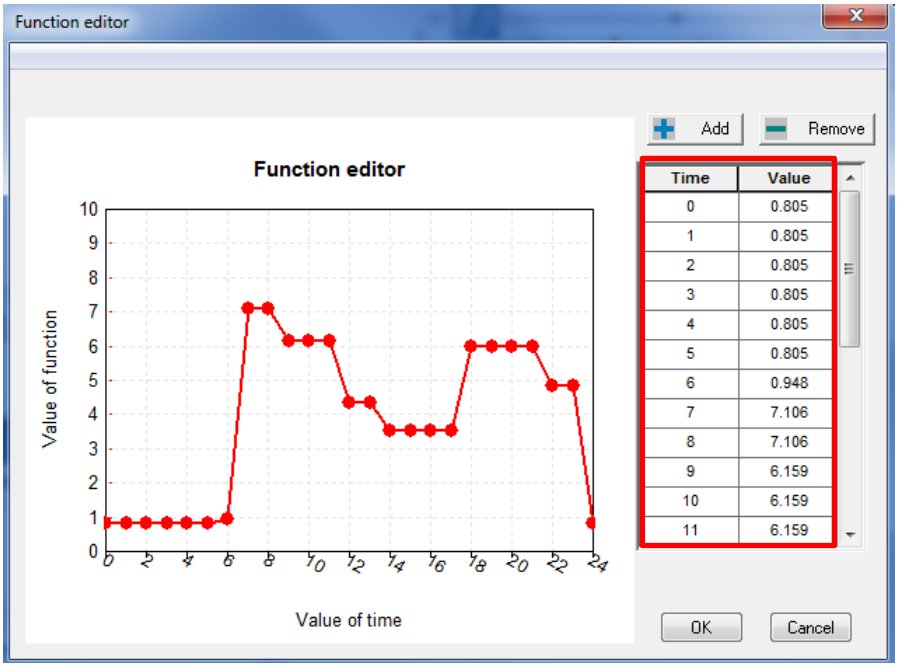


Figure 10-16 TRNSYS Component "Hot Water Demand" Settings

Figure 10-17 - Figure 10-20 present the simulation comparisons for ANALYSIS 6 (25 gallons/day) including Solar, Dhw, Aux and f factor. In Table 10-2, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

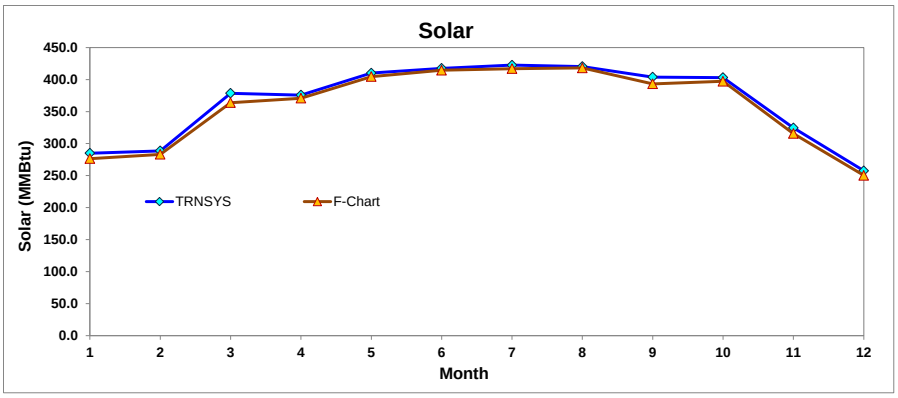


Figure 10-17 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 6 (25 gallons/day)

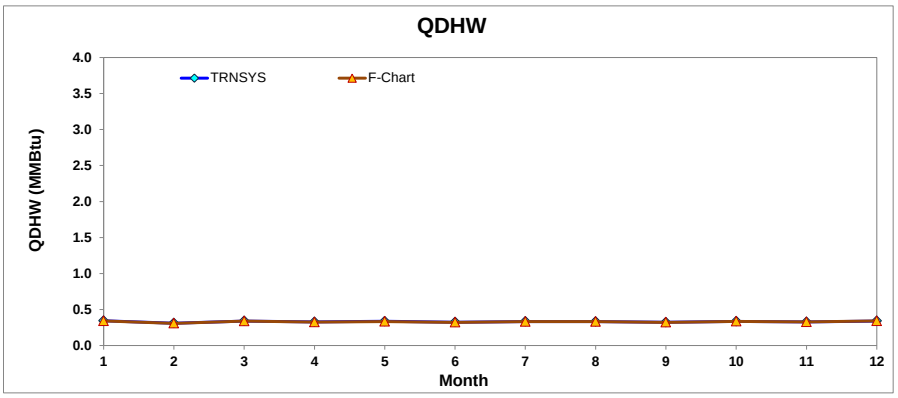


Figure 10-18Monthly Total Water Heating Demand -ANALYSIS 6 (25 gallons/day)

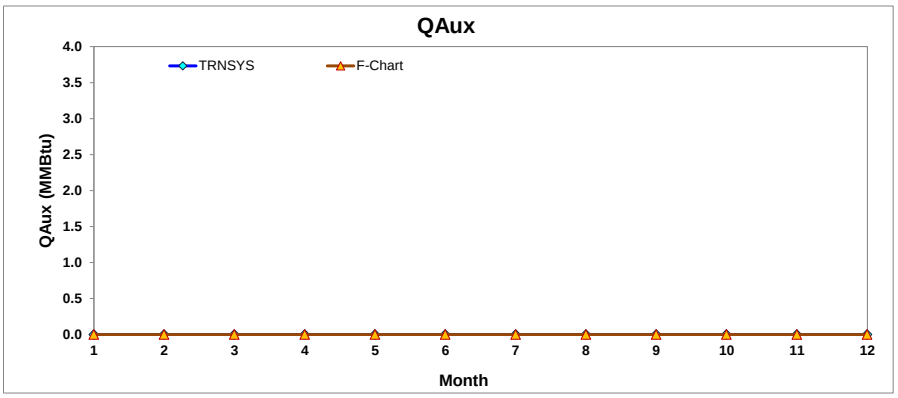


Figure 10-19Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 6 (25 gallons/day)

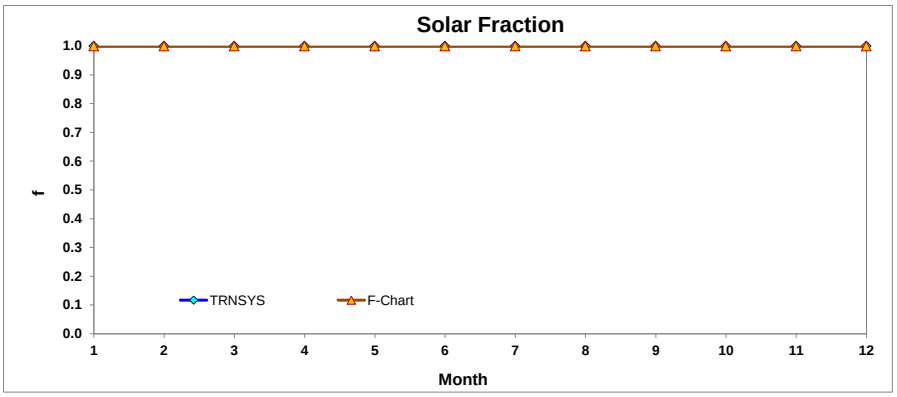


Figure 10-20Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 6 (25 gallons/day)

Table 10-2 Comparisons Data between TRNSYS and F-Chart ANALYSIS 6 (25 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	0.344	0.000	1.000	276.400	0.342	0.000	1.000	-3.1%	-0.5%	N/A	0.0%
Feb	288.558	0.310	0.000	1.000	283.200	0.308	0.000	1.000	-1.9%	0.7%	N/A	0.0%
Mar	378.561	0.341	0.000	1.000	363.900	0.339	0.000	1.000	-4.0%	0.5%	N/A	0.0%
Apr	375.729	0.328	0.000	1.000	370.800	0.325	0.000	1.000	-1.3%	0.9%	N/A	0.0%
May	410.133	0.337	0.000	1.000	404.600	0.334	0.000	1.000	-1.4%	0.8%	N/A	0.0%
Jun	417.508	0.324	0.000	1.000	414.500	0.322	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.580	0.333	0.000	1.000	417.000	0.332	0.000	1.000	-1.3%	0.3%	N/A	0.0%
Aug	420.326	0.332	0.000	1.000	418.200	0.332	0.000	1.000	-0.5%	0.0%	N/A	0.0%
Sep	403.892	0.323	0.000	1.000	393.300	0.322	0.000	1.000	-2.7%	0.4%	N/A	0.0%
Oct	403.004	0.336	0.000	1.000	397.200	0.336	0.000	1.000	-1.5%	0.0%	N/A	0.0%
Nov	324.518	0.328	0.000	1.000	315.700	0.328	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	257.535	0.341	0.000	1.000	250.300	0.341	0.000	1.000	-2.9%	0.0%	N/A	0.0%
Year	4387.304	3.977	0.000	1.000	4305.200	3.962	0.000	1.000	-1.9%	0.4%	N/A	0.0%

10.4 Analysis 6-55 Gallons/Day

The total collector area is 8000 ft^2 and daily hot water usage is 55 gallons/day with the storage tank volume 9488 gallons.

10.4.1 F-Chart simulation

Figure 10-21 and Figure 10-22 show the input information for F-Chart. The changed settings are presented in a red box. Figure 10-23 gives the result summary of modified simulation.

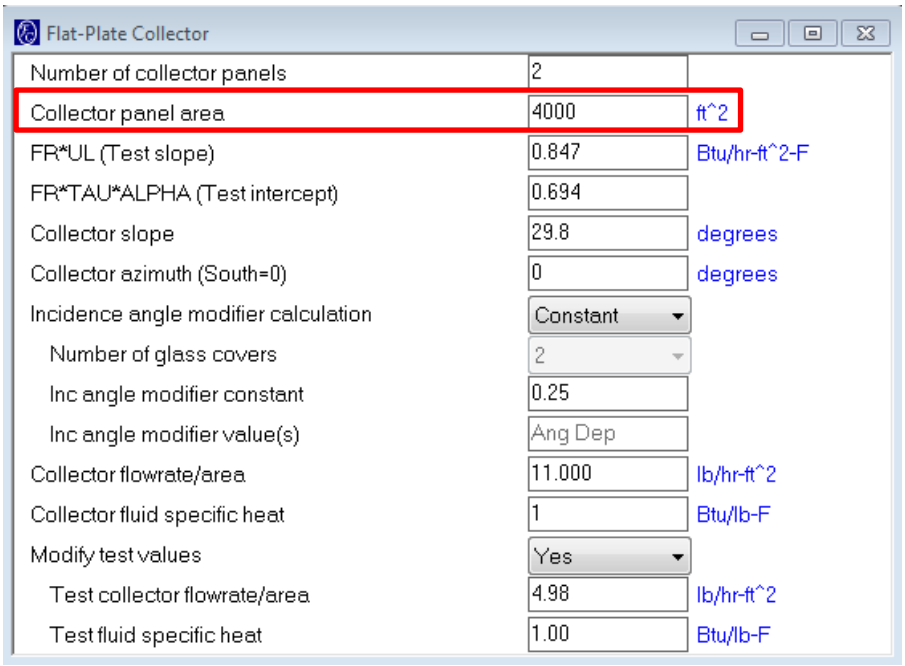


Figure 10-21 Flat-Plate Collector Input

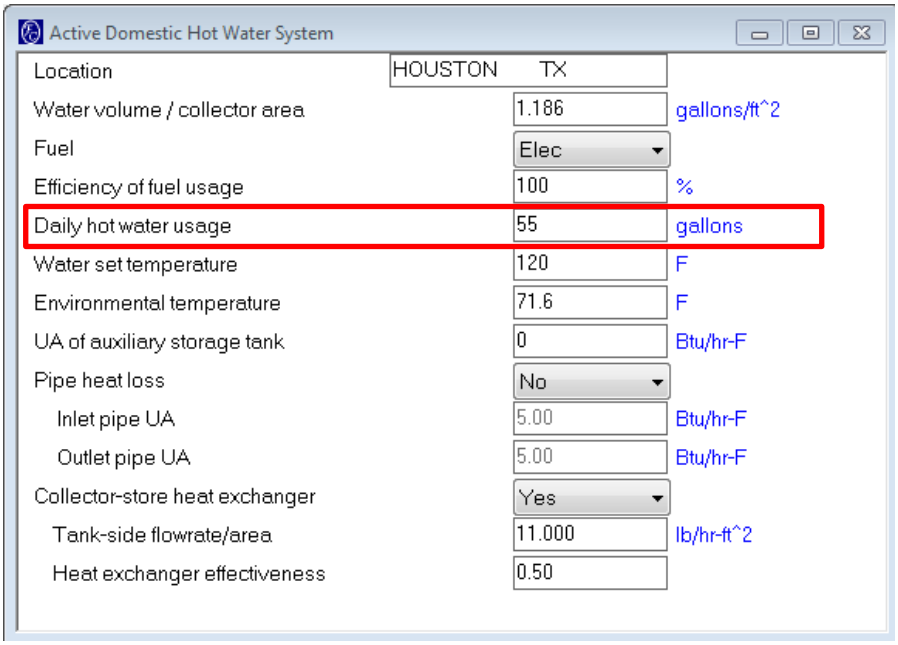
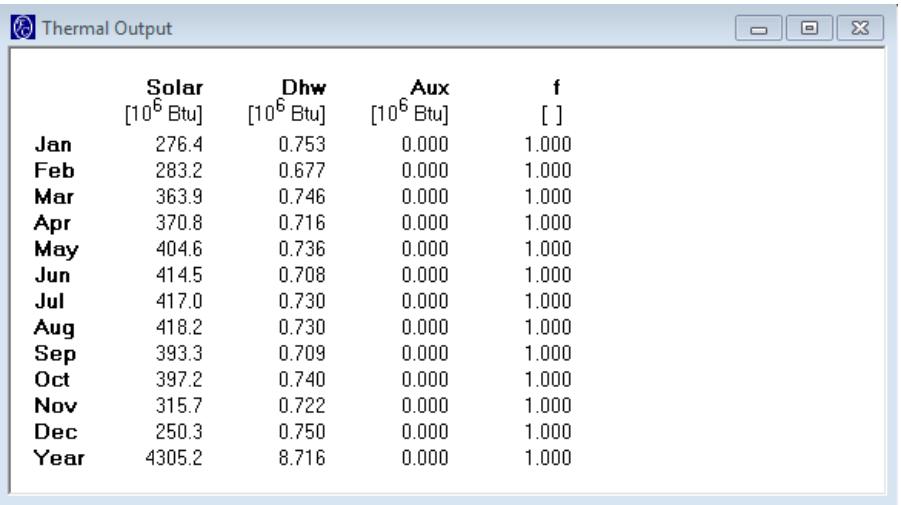


Figure 10-22 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	0.753	0.000	1.000
Feb	283.2	0.677	0.000	1.000
Mar	363.9	0.746	0.000	1.000
Apr	370.8	0.716	0.000	1.000
May	404.6	0.736	0.000	1.000
Jun	414.5	0.708	0.000	1.000
Jul	417.0	0.730	0.000	1.000
Aug	418.2	0.730	0.000	1.000
Sep	393.3	0.709	0.000	1.000
Oct	397.2	0.740	0.000	1.000
Nov	315.7	0.722	0.000	1.000
Dec	250.3	0.750	0.000	1.000
Year	4305.2	8.716	0.000	1.000

Figure 10-23 F-Chart Simulation

10.4.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 10-24, Figure 10-25 and Figure 10-26.

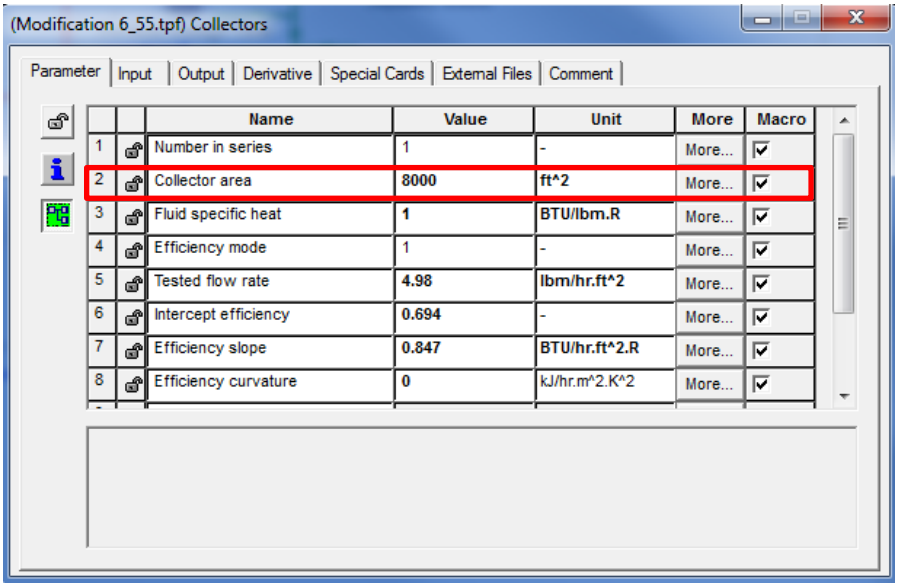


Figure 10-24 TRNSYS Component “Collectors” Settings

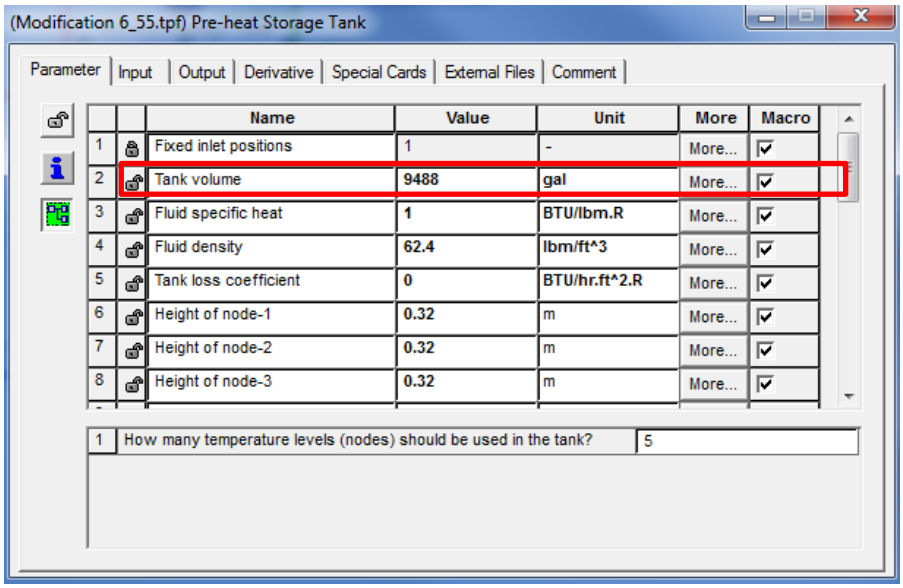


Figure 10-25 TRNSYS Component "Pre-heat Storage tank" Settings

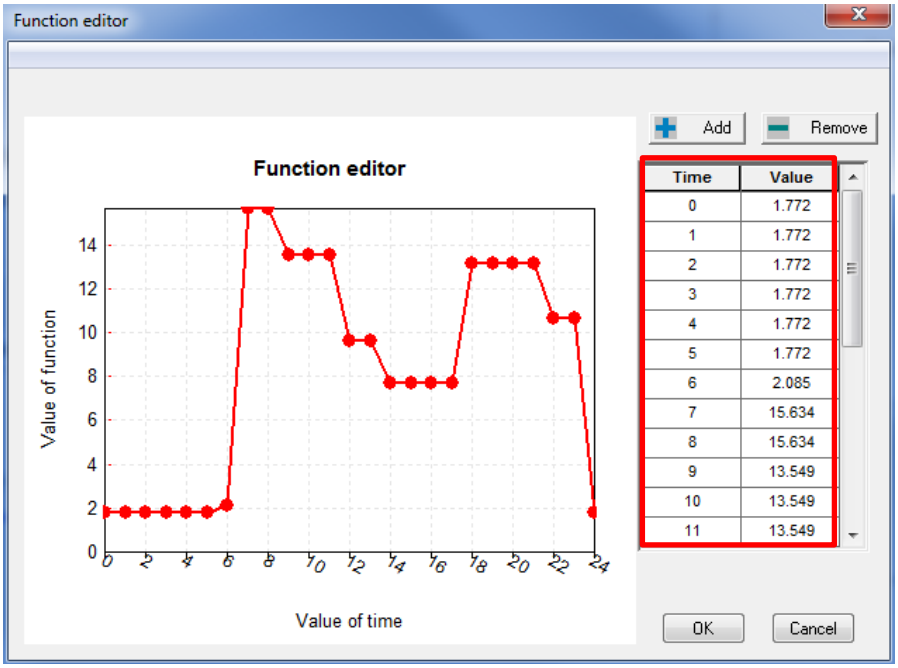


Figure 10-26 TRNSYS Component "Hot Water Demand" Settings

Figure 10-27 - Figure 10-30 present the simulation comparisons for ANALYSIS 6 (55 gallons/day) including Solar, Dhw, Aux and f factor. In Table 10-3, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

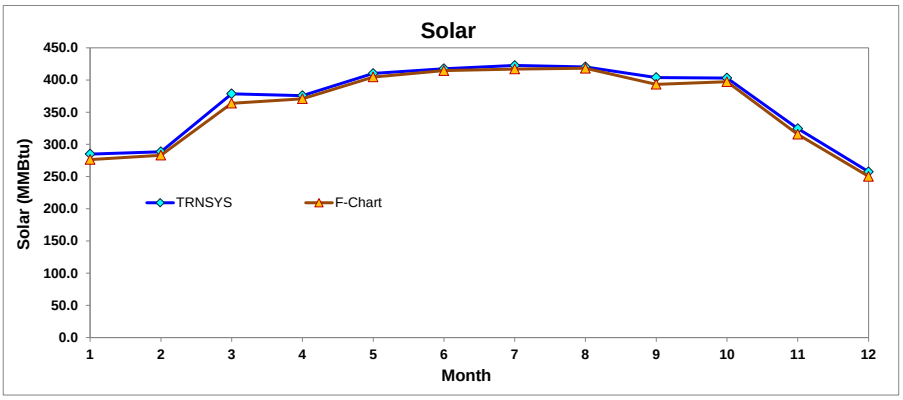


Figure 10-27 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 6 (55 gallons/day)

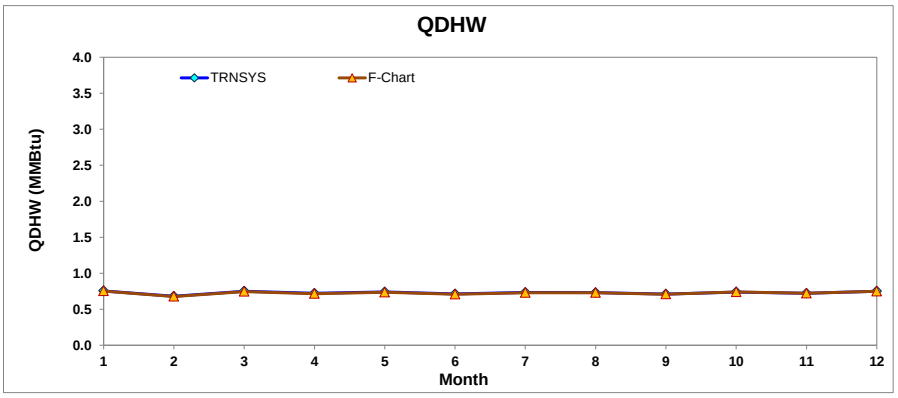


Figure 10-28Monthly Total Water Heating Demand -ANALYSIS 6 (55 gallons/day)

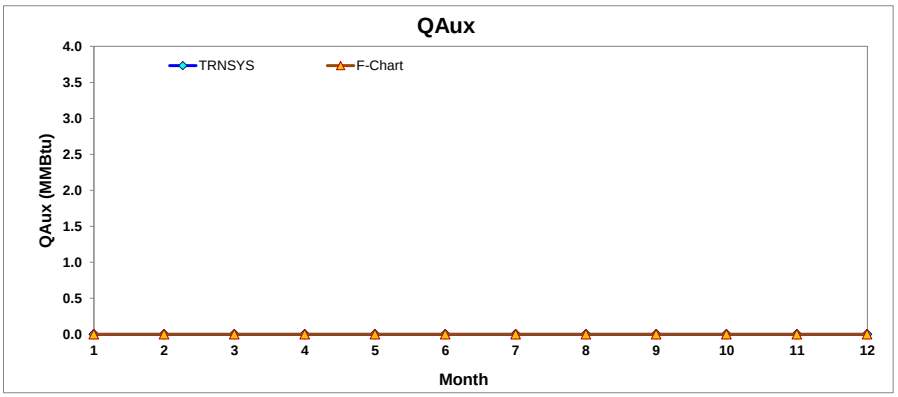


Figure 10-29Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 6 (55 gallons/day)

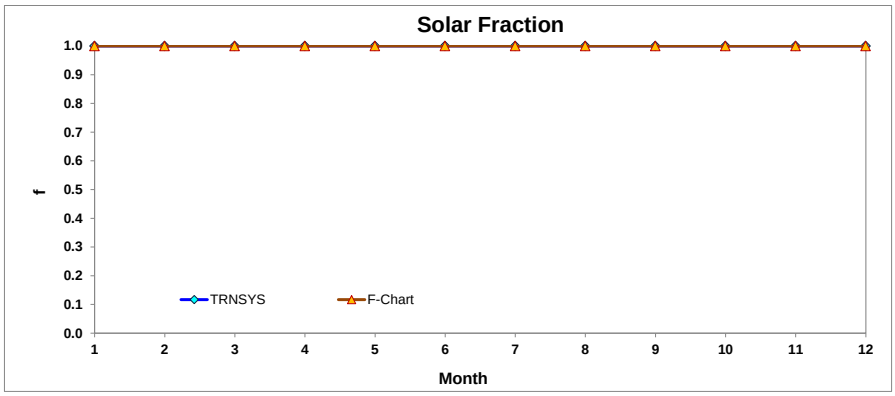


Figure 10-30Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 6 (55 gallons/day)

Table 10-3 Comparisons Data between TRNSYS and F-Chart ANALYSIS 6 (55 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	0.755	0.000	1.000	276.400	0.753	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	288.558	0.681	0.000	1.000	283.200	0.677	0.000	1.000	-1.9%	0.6%	N/A	0.0%
Mar	378.561	0.751	0.000	1.000	363.900	0.746	0.000	1.000	-4.0%	0.6%	N/A	0.0%
Apr	375.729	0.722	0.000	1.000	370.800	0.716	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	410.133	0.741	0.000	1.000	404.600	0.736	0.000	1.000	-1.4%	0.6%	N/A	0.0%
Jun	417.508	0.712	0.000	1.000	414.500	0.708	0.000	1.000	-0.7%	0.6%	N/A	0.0%
Jul	422.580	0.734	0.000	1.000	417.000	0.730	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	420.326	0.732	0.000	1.000	418.200	0.730	0.000	1.000	-0.5%	0.2%	N/A	0.0%
Sep	403.892	0.711	0.000	1.000	393.300	0.709	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	403.004	0.739	0.000	1.000	397.200	0.740	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	324.518	0.722	0.000	1.000	315.700	0.722	0.000	1.000	-2.8%	0.1%	N/A	0.0%
Dec	257.535	0.751	0.000	1.000	250.300	0.750	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	4387.304	8.750	0.000	1.000	4305.200	8.716	0.000	1.000	-1.9%	0.4%	N/A	0.0%

10.5 Analysis 6-85 Gallons/Day

The total collector area is 8000 ft^2 and daily hot water usage is 85 gallons/day with the storage tank volume 9488 gallons.

10.5.1 F-Chart simulation

Figure 10-31 and Figure 10-32 show the input information for F-Chart. The changed settings are presented in a red box. Figure 10-33 gives the result summary of modified simulation.

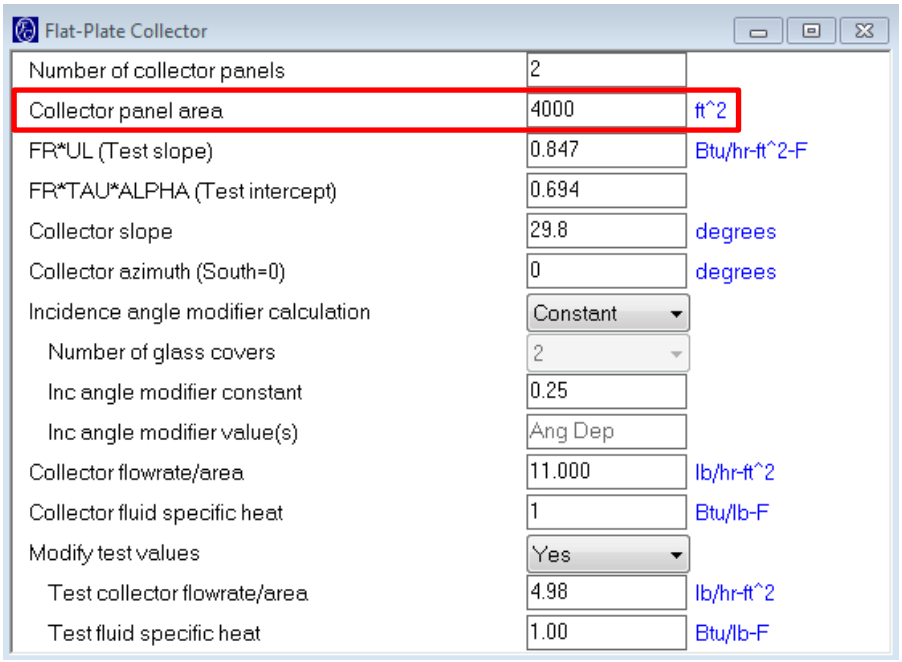


Figure 10-31 Flat-Plate Collector Input

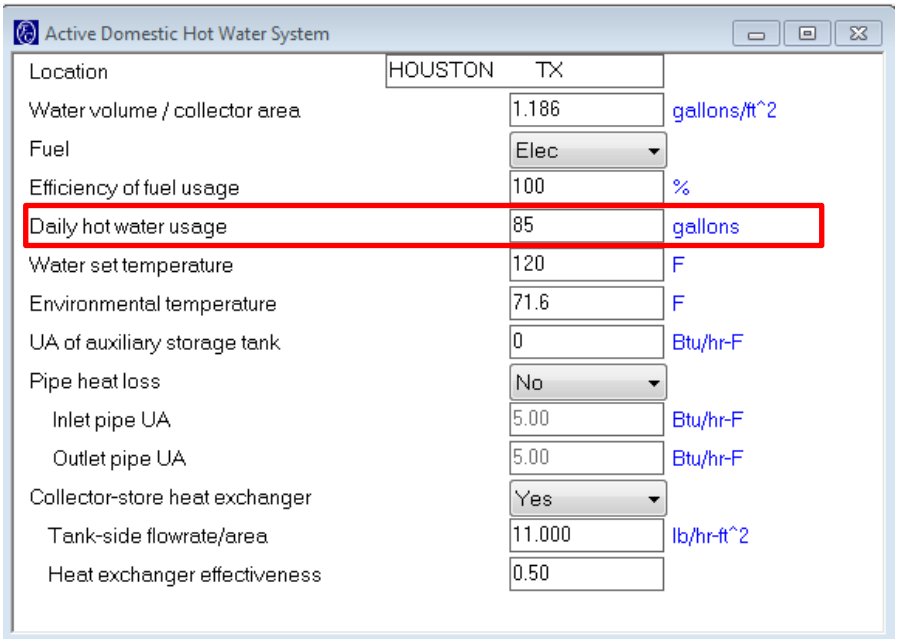
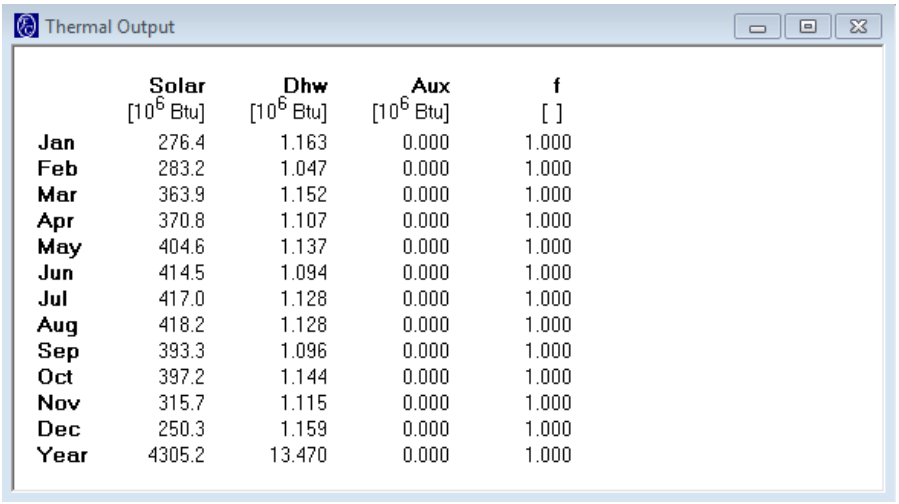


Figure 10-32 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	1.163	0.000	1.000
Feb	283.2	1.047	0.000	1.000
Mar	363.9	1.152	0.000	1.000
Apr	370.8	1.107	0.000	1.000
May	404.6	1.137	0.000	1.000
Jun	414.5	1.094	0.000	1.000
Jul	417.0	1.128	0.000	1.000
Aug	418.2	1.128	0.000	1.000
Sep	393.3	1.096	0.000	1.000
Oct	397.2	1.144	0.000	1.000
Nov	315.7	1.115	0.000	1.000
Dec	250.3	1.159	0.000	1.000
Year	4305.2	13.470	0.000	1.000

Figure 10-33 F-Chart Simulation

10.5.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 10-34, Figure 10-35 and Figure 10-36.

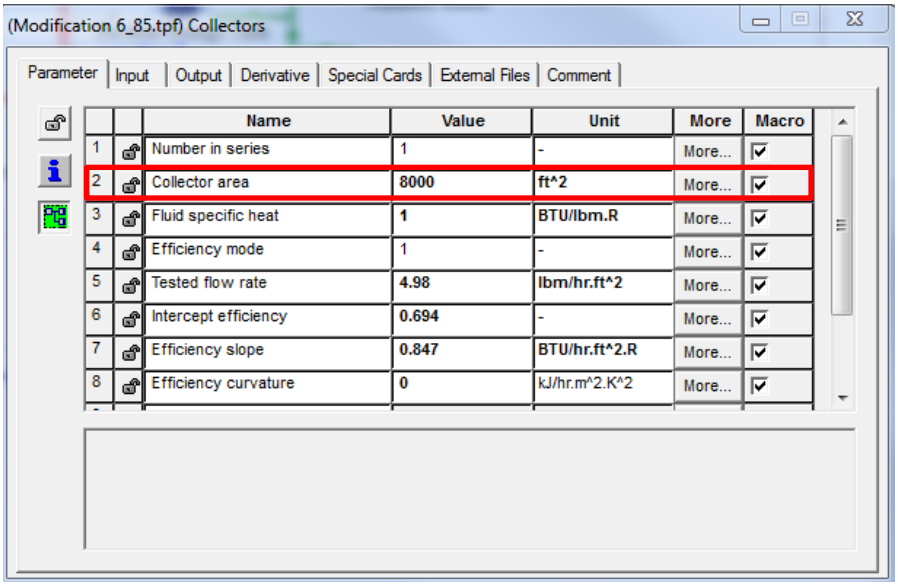


Figure 10-34 TRNSYS Component “Collectors” Settings

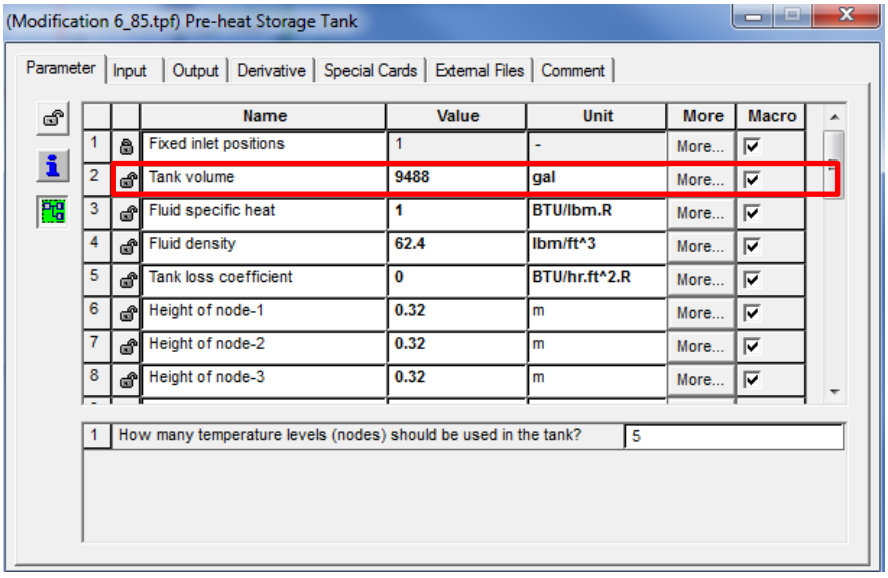


Figure 10-35 TRNSYS Component "Pre-heat Storage tank" Settings

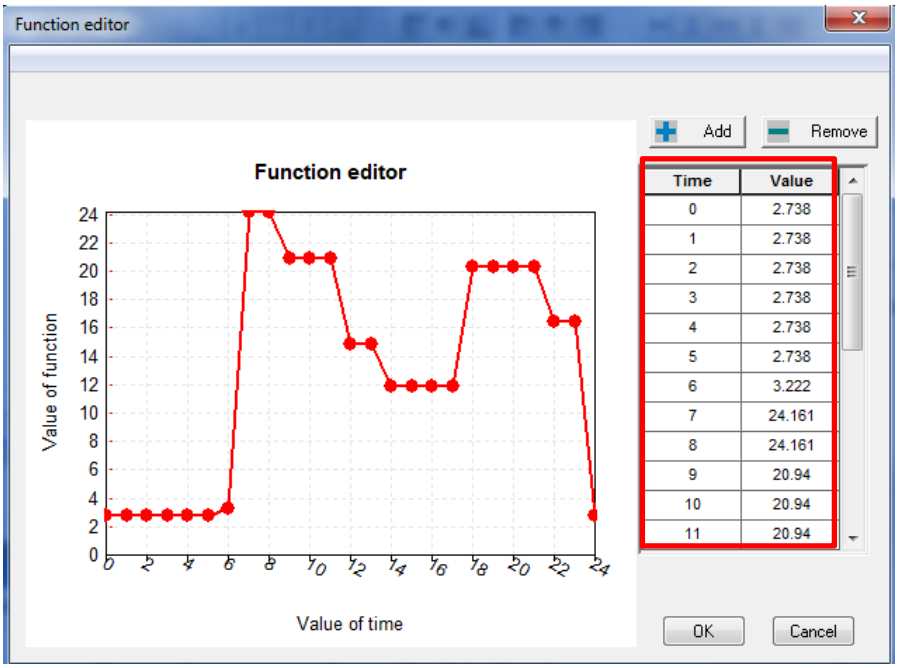


Figure 10-36 TRNSYS Component "Hot Water Demand" Settings

Figure 10-37 - Figure 10-40 present the simulation comparisons for ANALYSIS 6 (85 gallons/day) including Solar, Dhw, Aux and f factor. In Table 10-4, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

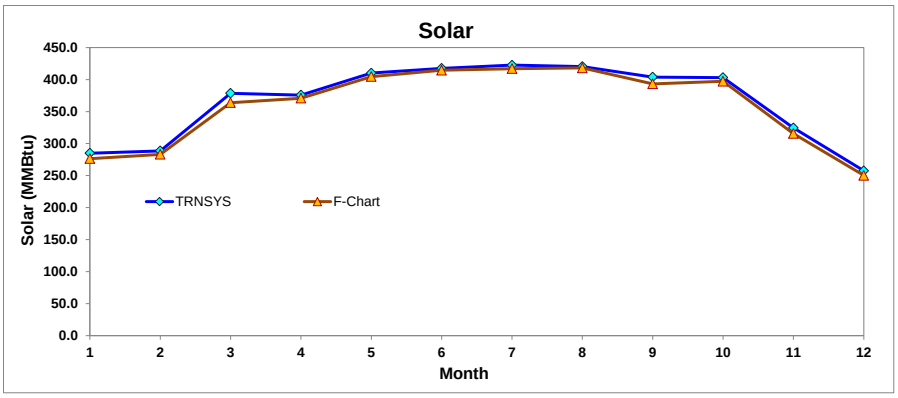


Figure 10-37 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 6 (85 gallons/day)

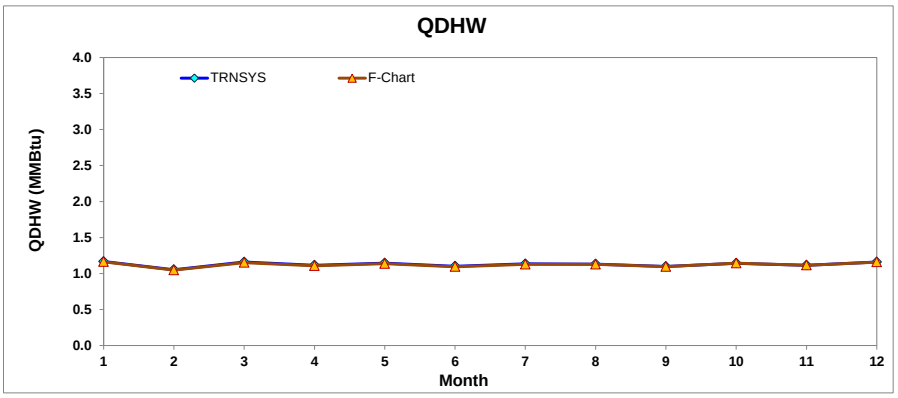


Figure 10-38Monthly Total Water Heating Demand -ANALYSIS 6 (85 gallons/day)

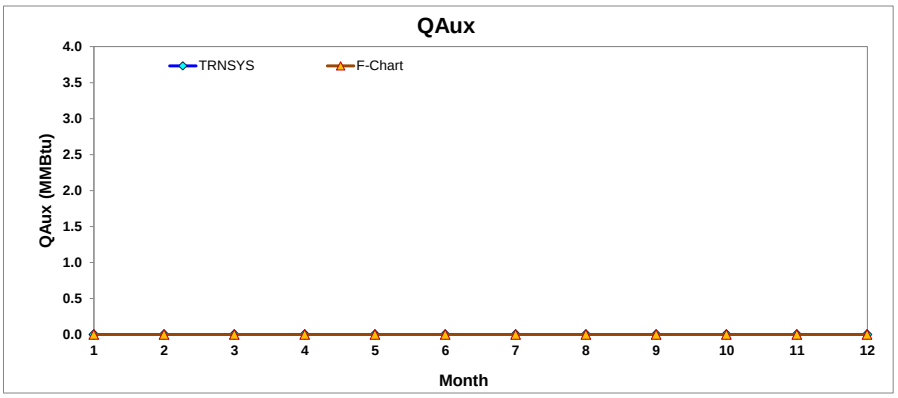


Figure 10-39Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 6 (85 gallons/day)

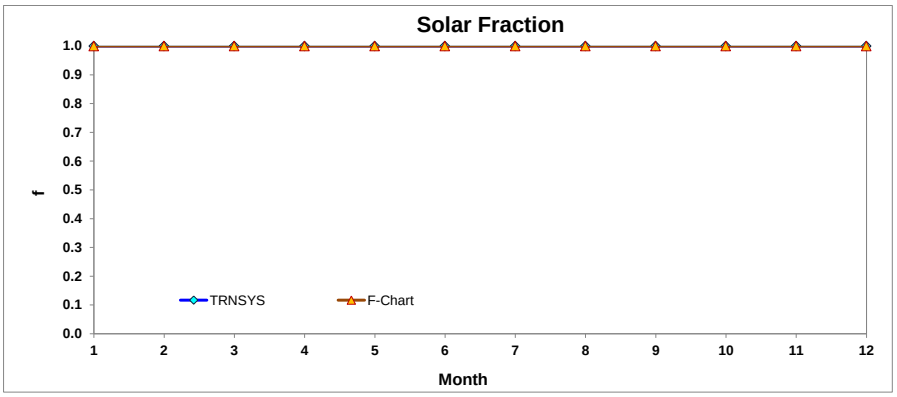


Figure 10-40Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 6 (85 gallons/day)

Table 10-4 Comparisons Data between TRNSYS and F-Chart ANALYSIS 5 (85 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	1.166	0.000	1.000	276.400	1.163	0.000	1.000	-3.1%	-0.3%	N/A	0.0%
Feb	288.558	1.053	0.000	1.000	283.200	1.047	0.000	1.000	-1.9%	0.5%	N/A	0.0%
Mar	378.561	1.160	0.000	1.000	363.900	1.152	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	375.729	1.115	0.000	1.000	370.800	1.107	0.000	1.000	-1.3%	0.7%	N/A	0.0%
May	410.133	1.145	0.000	1.000	404.600	1.137	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.508	1.101	0.000	1.000	414.500	1.094	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.580	1.134	0.000	1.000	417.000	1.128	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	420.326	1.131	0.000	1.000	418.200	1.128	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	403.892	1.098	0.000	1.000	393.300	1.096	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	403.004	1.142	0.000	1.000	397.200	1.144	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	324.518	1.115	0.000	1.000	315.700	1.115	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	257.535	1.160	0.000	1.000	250.300	1.159	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	4387.304	13.522	0.000	1.000	4305.200	13.470	0.000	1.000	-1.9%	0.4%	N/A	0.0%

10.6 Analysis 6-115 Gallons/Day

The total collector area is 8000 ft^2 and daily hot water usage is 115 gallons/day with the storage tank volume 9488 gallons.

10.6.1 F-Chart simulation

Figure 10-41 and Figure 10-42 show the input information for F-Chart. The changed settings are presented in a red box. Figure 10-43 gives the result summary of modified simulation.

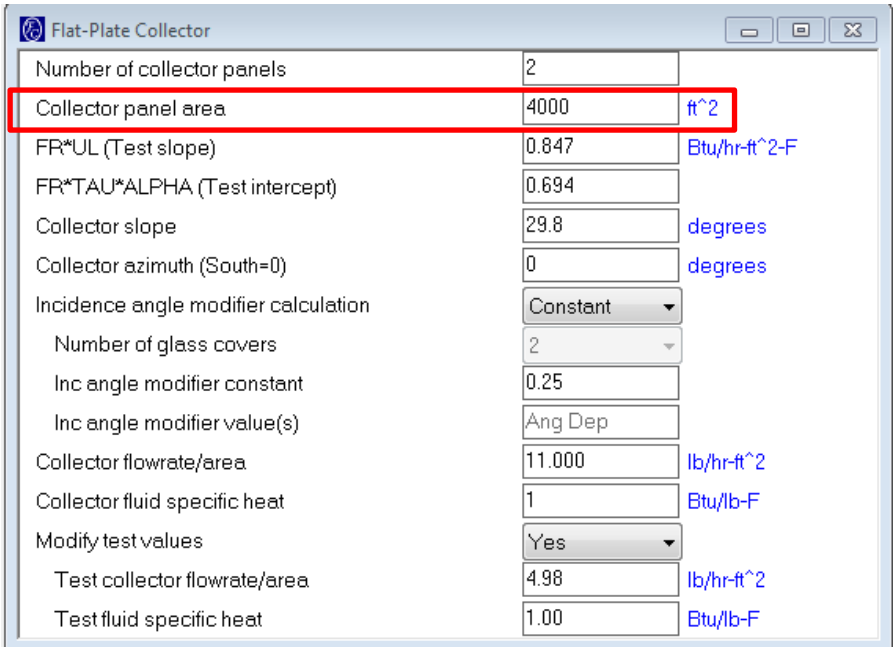


Figure 10-41 Flat-Plate Collector Input

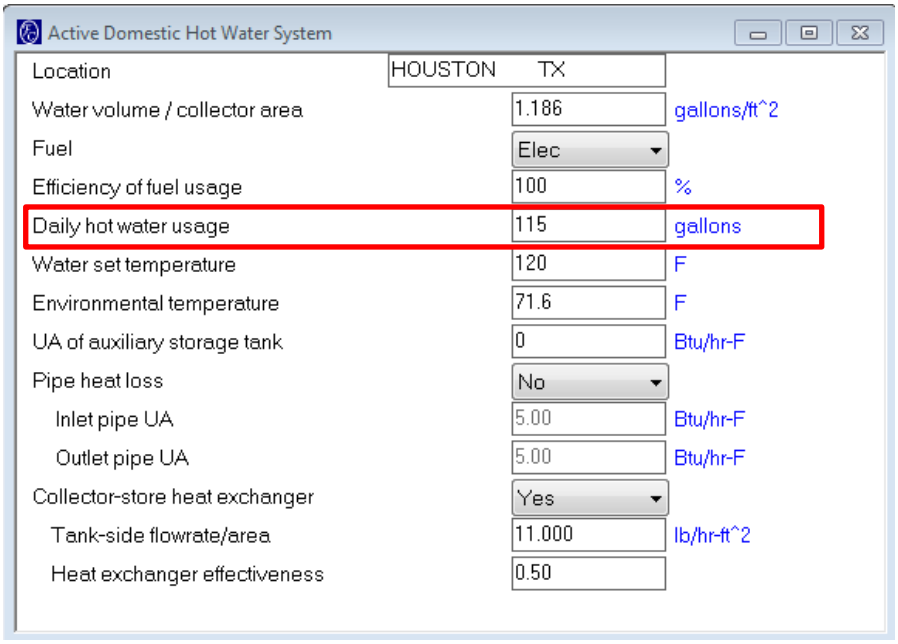
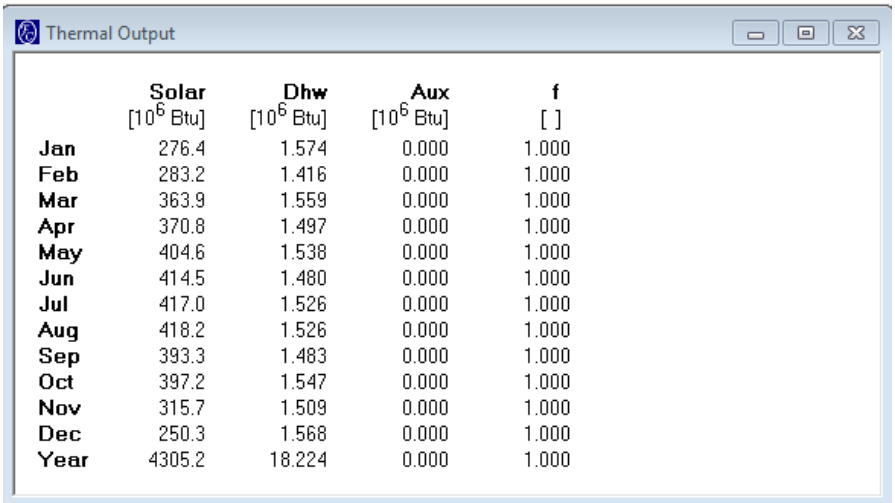


Figure 10-42 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	1.574	0.000	1.000
Feb	283.2	1.416	0.000	1.000
Mar	363.9	1.559	0.000	1.000
Apr	370.8	1.497	0.000	1.000
May	404.6	1.538	0.000	1.000
Jun	414.5	1.480	0.000	1.000
Jul	417.0	1.526	0.000	1.000
Aug	418.2	1.526	0.000	1.000
Sep	393.3	1.483	0.000	1.000
Oct	397.2	1.547	0.000	1.000
Nov	315.7	1.509	0.000	1.000
Dec	250.3	1.568	0.000	1.000
Year	4305.2	18.224	0.000	1.000

Figure 10-43 F-Chart Simulation

10.6.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 10-44 , Figure 10-45 and Figure 10-46.

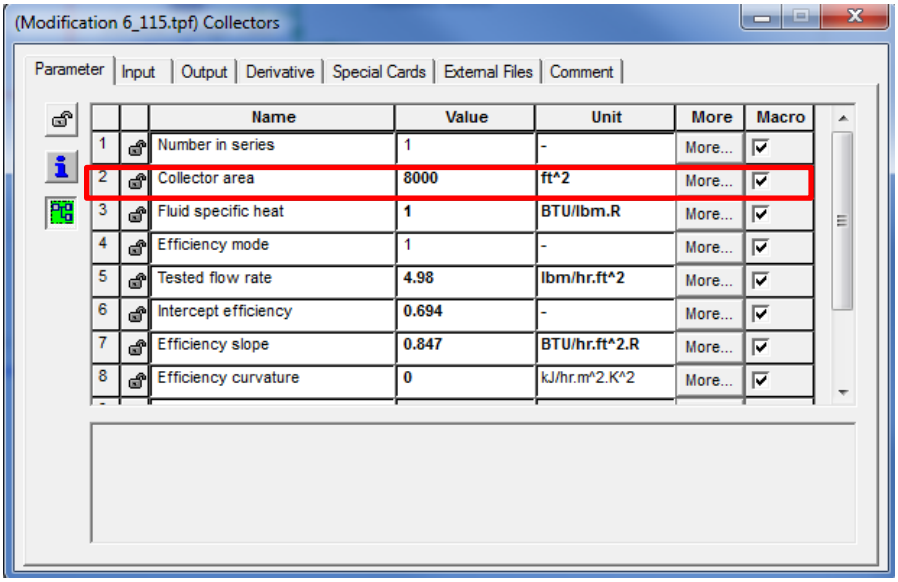


Figure 10-44 TRNSYS Component “Collectors” Settings

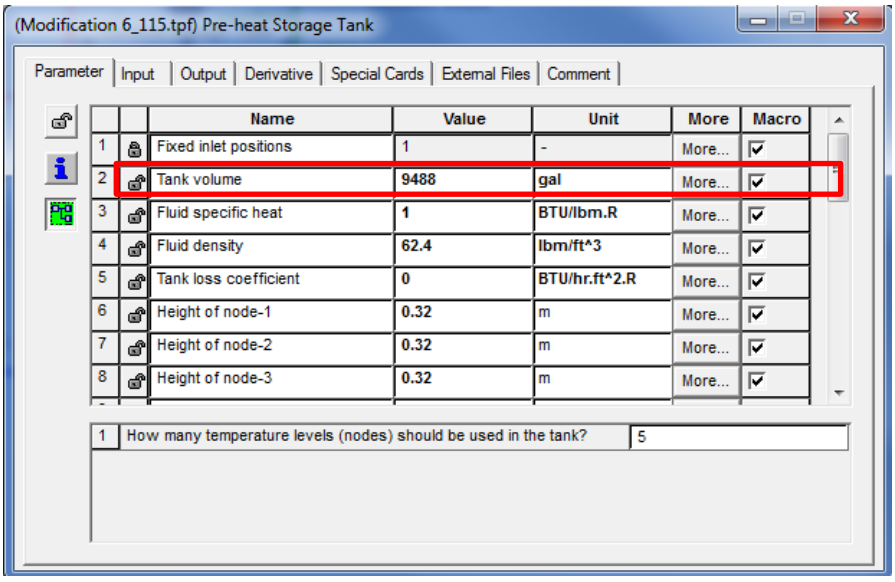


Figure 10-45 TRNSYS Component "Pre-heat Storage tank" Settings

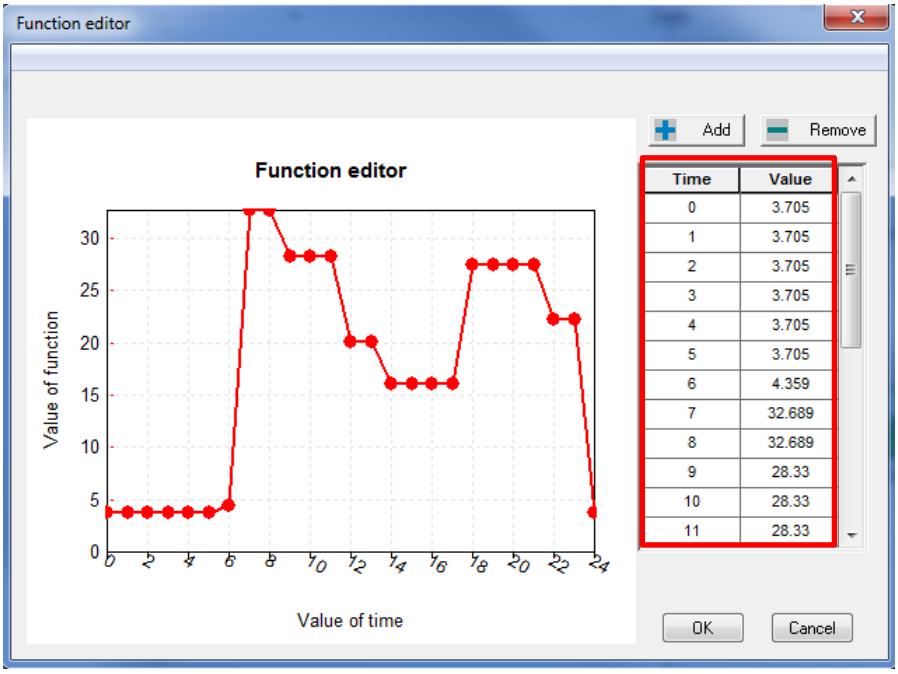


Figure 10-46 TRNSYS Component "Hot Water Demand" Settings

Figure 10-47 - Figure 10-50 present the simulation comparisons for ANALYSIS 6 (115 gallons/day) including Solar, Dhw, Aux and f factor. In Table 10-5, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 0 %, respectively.

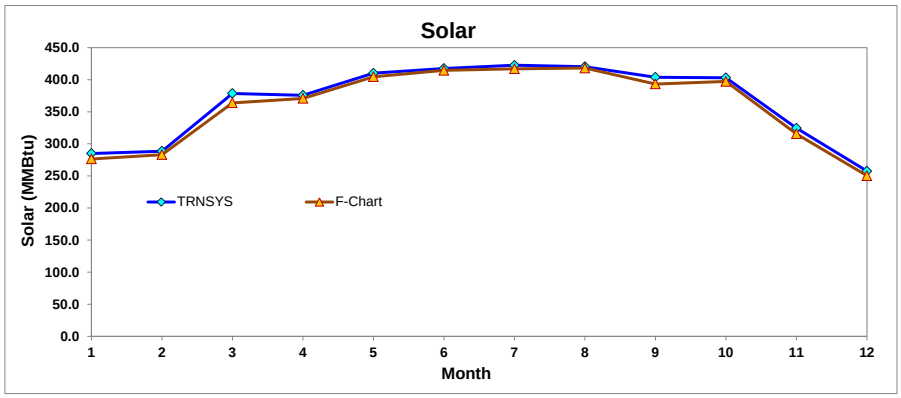


Figure 10-47 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 6 (115 gallons/day)

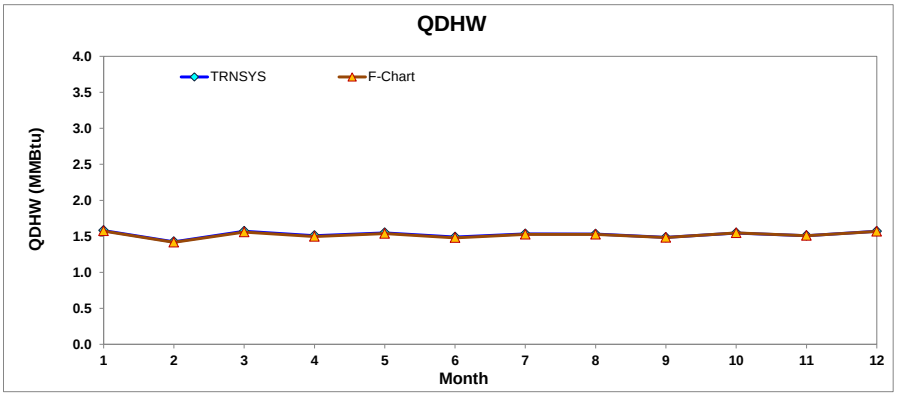


Figure 10-48Monthly Total Water Heating Demand -ANALYSIS 6 (115 gallons/day)

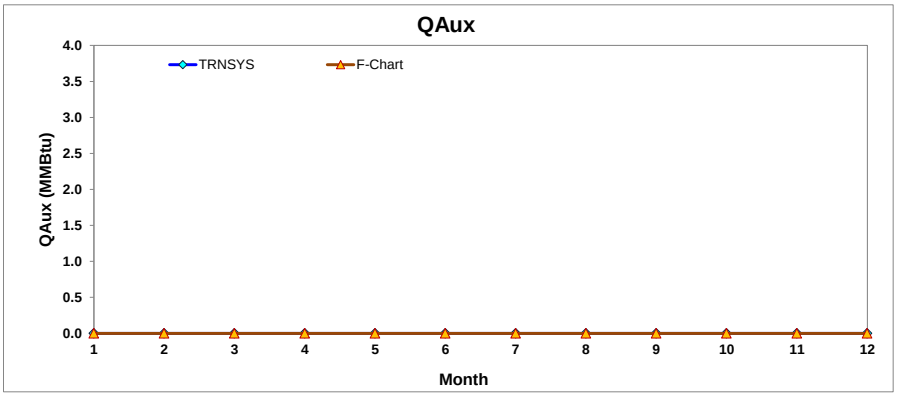


Figure 10-49Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 6 (115 gallons/day)

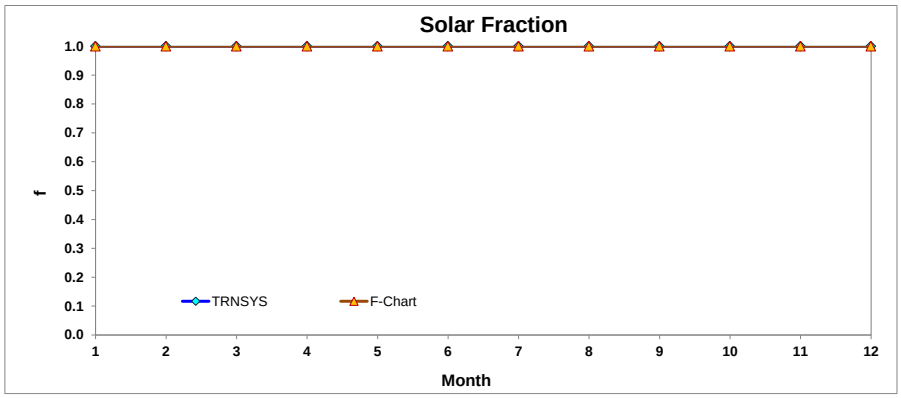


Figure 10-50Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 6 (115 gallons/day)

Table 10-5 Comparisons Data between TRNSYS and F-Chart ANALYSIS 6 (115 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	1.581	0.000	1.000	276.400	1.574	0.000	1.000	-3.1%	-0.4%	N/A	0.0%
Feb	288.558	1.424	0.000	1.000	283.200	1.416	0.000	1.000	-1.9%	0.6%	N/A	0.0%
Mar	378.561	1.569	0.000	1.000	363.900	1.559	0.000	1.000	-4.0%	0.7%	N/A	0.0%
Apr	375.729	1.509	0.000	1.000	370.800	1.497	0.000	1.000	-1.3%	0.8%	N/A	0.0%
May	410.133	1.549	0.000	1.000	404.600	1.538	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.508	1.490	0.000	1.000	414.500	1.480	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.580	1.534	0.000	1.000	417.000	1.526	0.000	1.000	-1.3%	0.5%	N/A	0.0%
Aug	420.326	1.531	0.000	1.000	418.200	1.526	0.000	1.000	-0.5%	0.3%	N/A	0.0%
Sep	403.892	1.486	0.000	1.000	393.300	1.483	0.000	1.000	-2.7%	0.2%	N/A	0.0%
Oct	403.004	1.546	0.000	1.000	397.200	1.547	0.000	1.000	-1.5%	0.1%	N/A	0.0%
Nov	324.518	1.509	0.000	1.000	315.700	1.509	0.000	1.000	-2.8%	0.0%	N/A	0.0%
Dec	257.535	1.569	0.000	1.000	250.300	1.568	0.000	1.000	-2.9%	0.1%	N/A	0.0%
Year	4387.304	18.296	0.000	1.000	4305.200	18.224	0.000	1.000	-1.9%	0.4%	N/A	0.0%

10.7 Analysis 6-461 Gallons/Day

The total collector area is 8000 ft^2 and daily hot water usage is 461 gallons/day with the storage tank volume 9488 gallons.

10.7.1 F-Chart simulation

Figure 10-51 and Figure 10-52 show the input information for F-Chart. The changed settings are presented in a red box. Figure 10-53 gives the result summary of modified simulation.

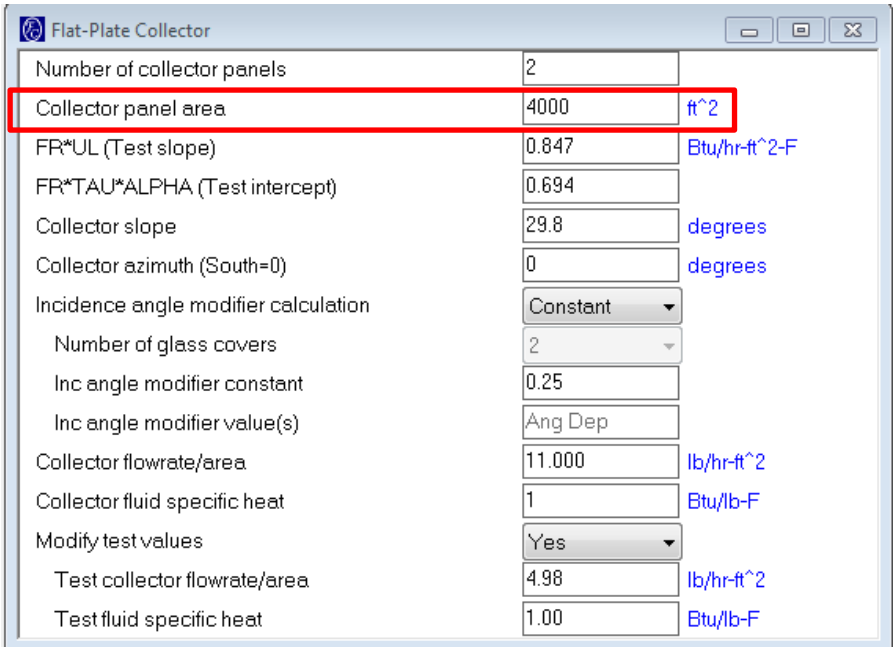


Figure 10-51 Flat-Plate Collector Input

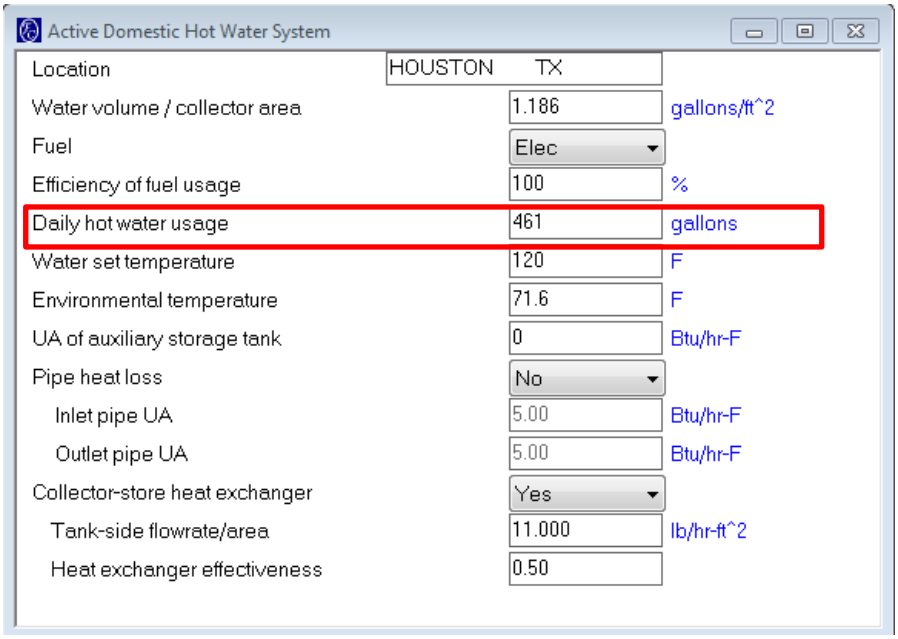
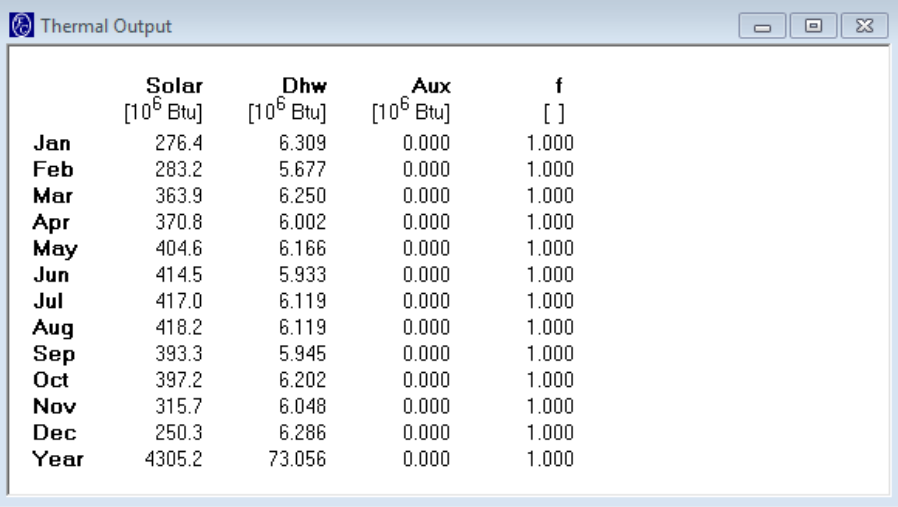


Figure 10-52 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	6.309	0.000	1.000
Feb	283.2	5.677	0.000	1.000
Mar	363.9	6.250	0.000	1.000
Apr	370.8	6.002	0.000	1.000
May	404.6	6.166	0.000	1.000
Jun	414.5	5.933	0.000	1.000
Jul	417.0	6.119	0.000	1.000
Aug	418.2	6.119	0.000	1.000
Sep	393.3	5.945	0.000	1.000
Oct	397.2	6.202	0.000	1.000
Nov	315.7	6.048	0.000	1.000
Dec	250.3	6.286	0.000	1.000
Year	4305.2	73.056	0.000	1.000

Figure 10-53 F-Chart Simulation

10.7.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 10-54 , Figure 10-55 and Figure 10-56.

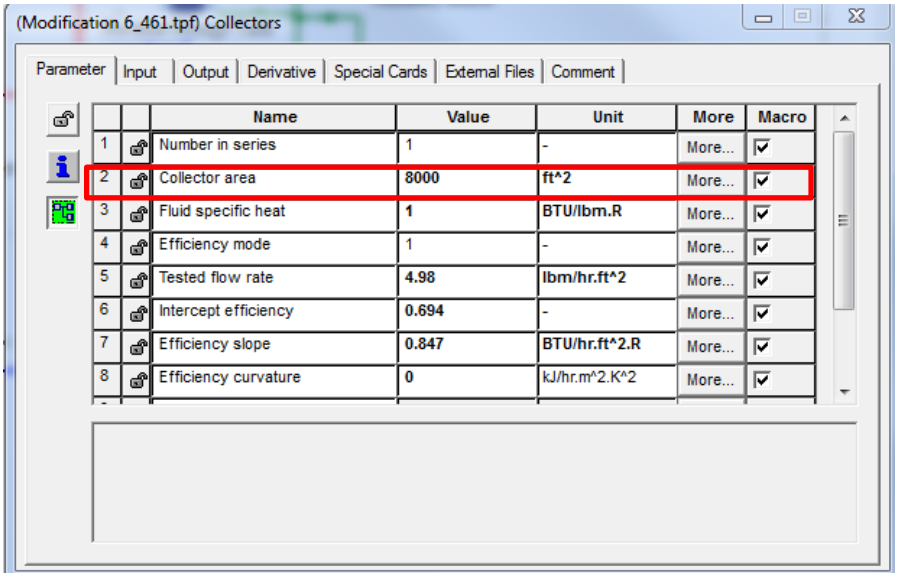


Figure 10-54 TRNSYS Component “Collectors” Settings

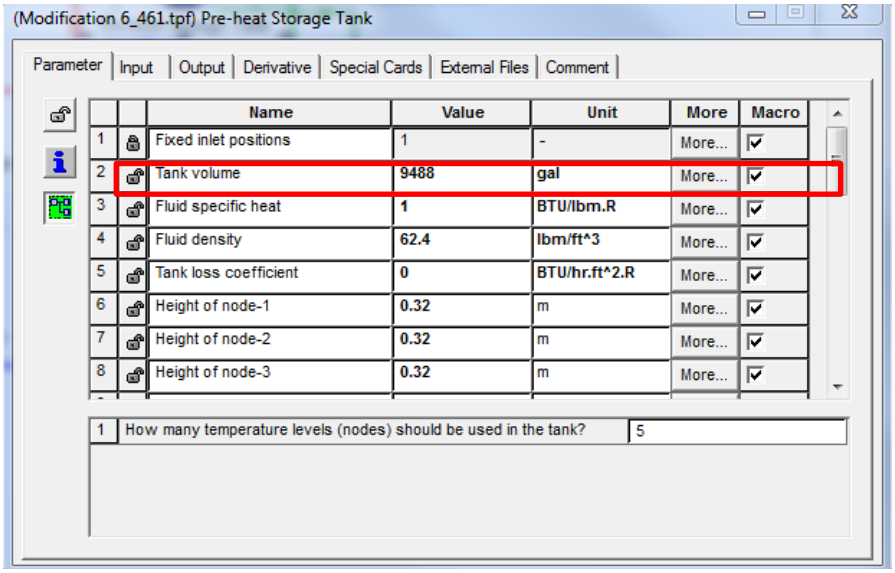


Figure 10-55 TRNSYS Component "Pre-heat Storage tank" Settings

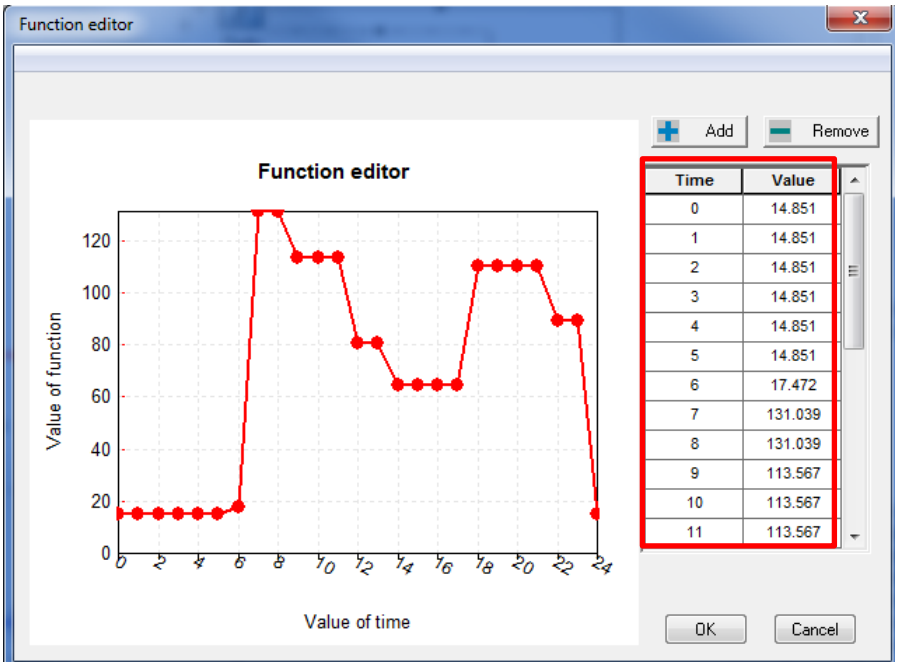


Figure 10-56 TRNSYS Component "Hot Water Demand" Settings

Figure 10-57 - Figure 10-60 present the simulation comparisons for ANALYSIS 6 (461 gallons/day) including Solar, Dhw, Aux and f factor. In Table 10-6, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 1.1 %, respectively.

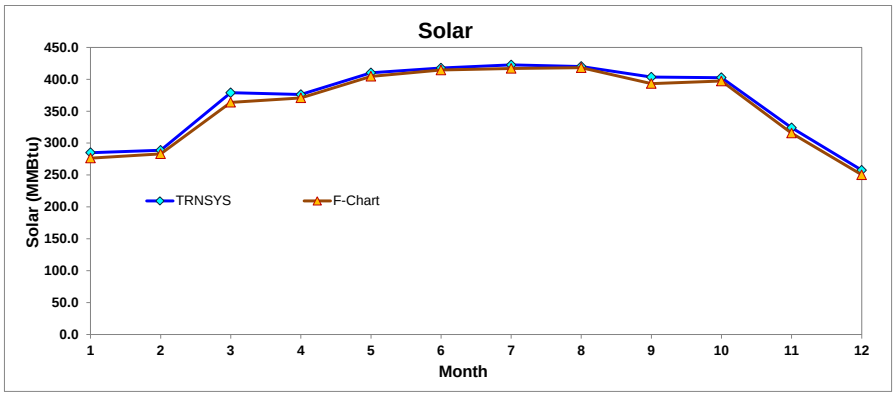


Figure 10-57 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 6 (461 gallons/day)

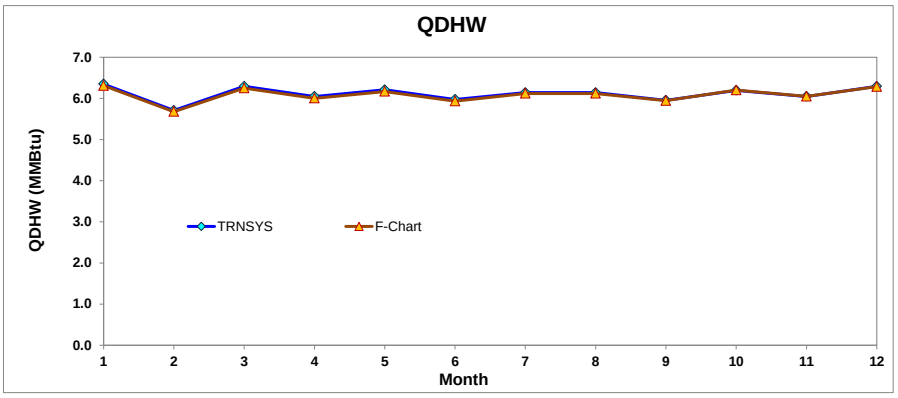


Figure 10-58Monthly Total Water Heating Demand -ANALYSIS 6 (461 gallons/day)

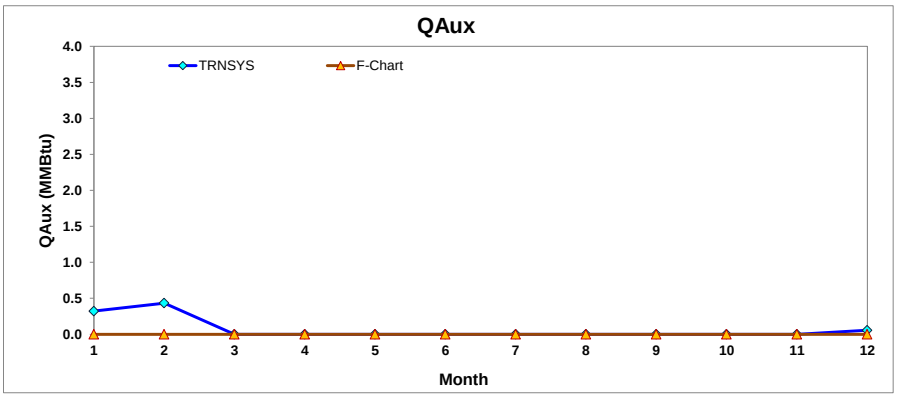


Figure 10-59Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 6 (461 gallons/day)

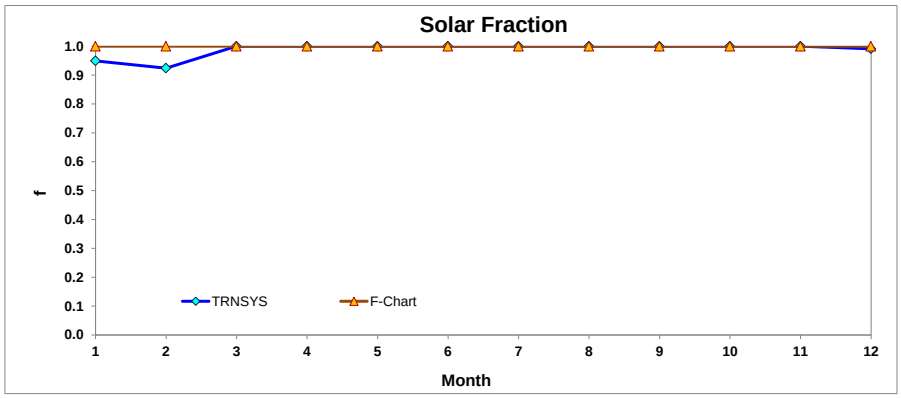


Figure 10-60Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 6 (461 gallons/day)

Table 10-6 Comparisons Data between TRNSYS and F-Chart ANALYSIS 6 (461 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	6.347	0.322	0.949	276.400	6.309	0.000	1.000	-3.1%	-0.6%	N/A	5.1%
Feb	288.769	5.708	0.433	0.924	283.200	5.677	0.000	1.000	-2.0%	0.5%	N/A	7.6%
Mar	378.920	6.294	0.000	1.000	363.900	6.250	0.000	1.000	-4.1%	0.7%	N/A	0.0%
Apr	376.152	6.046	0.000	1.000	370.800	6.002	0.000	1.000	-1.4%	0.7%	N/A	0.0%
May	410.133	6.209	0.000	1.000	404.600	6.166	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.579	5.974	0.000	1.000	414.500	5.933	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.510	6.141	0.000	1.000	417.000	6.119	0.000	1.000	-1.3%	0.4%	N/A	0.0%
Aug	420.044	6.141	0.000	1.000	418.200	6.119	0.000	1.000	-0.4%	0.4%	N/A	0.0%
Sep	403.469	5.955	0.000	1.000	393.300	5.945	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	402.511	6.196	0.000	1.000	397.200	6.202	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	324.088	6.046	0.000	1.000	315.700	6.048	0.000	1.000	-2.7%	0.0%	N/A	0.0%
Dec	257.458	6.294	0.056	0.991	250.300	6.286	0.000	1.000	-2.9%	0.1%	N/A	0.9%
Year	4386.592	73.350	0.811	0.989	4305.200	73.056	0.000	1.000	-1.9%	0.4%	N/A	1.1%

10.8 Analysis 6-462 Gallons/Day

The total collector area is 8000 ft^2 and daily hot water usage is 462 gallons/day with the storage tank volume 9488 gallons.

10.8.1 F-Chart simulation

Figure 10-61 and Figure 10-62 show the input information for F-Chart. The changed settings are presented in a red box. Figure 10-63 gives the result summary of modified simulation.

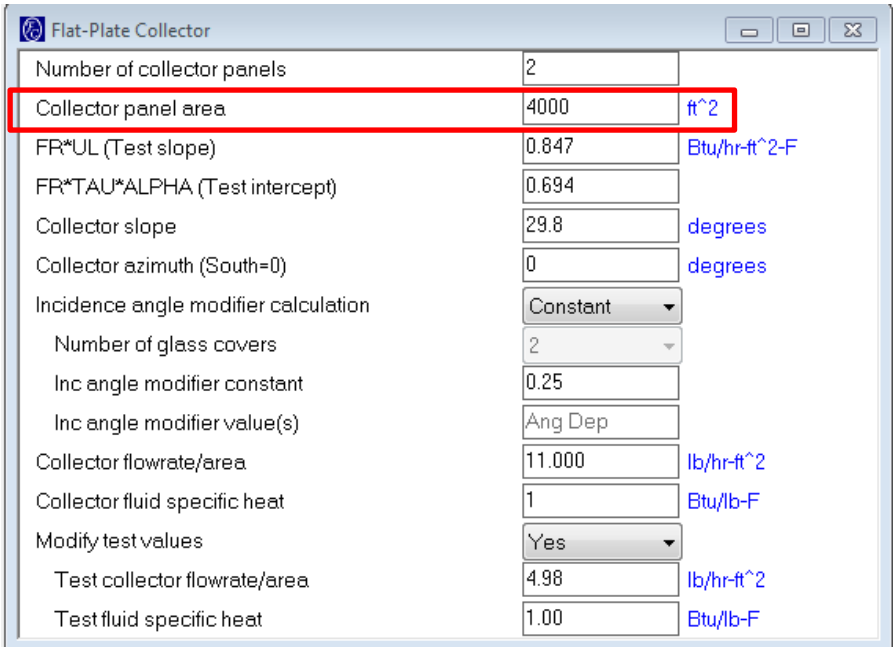


Figure 10-61 Flat-Plate Collector Input

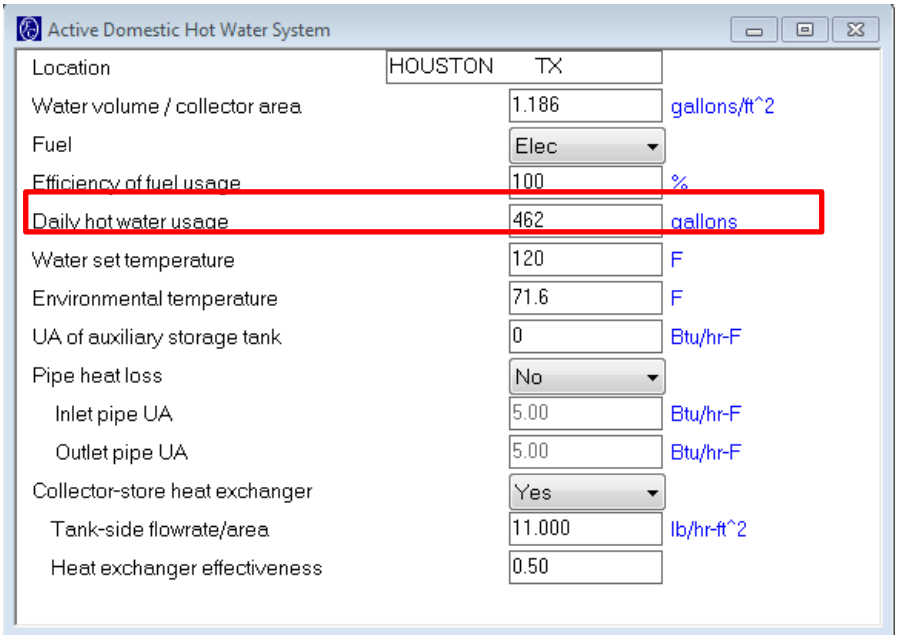
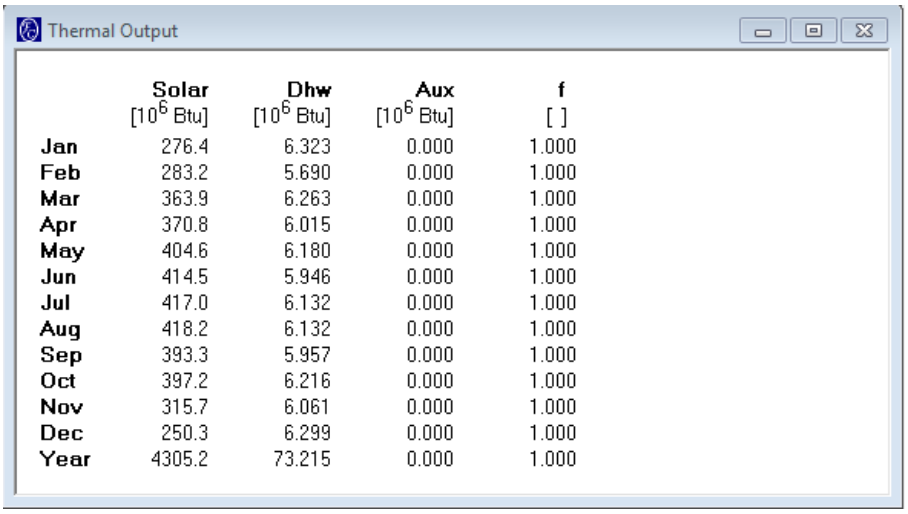


Figure 10-62 Active Domestic Hot Water System Input



	Solar [10^6 Btu]	Dhw [10^6 Btu]	Aux [10^6 Btu]	f [ ]
Jan	276.4	6.323	0.000	1.000
Feb	283.2	5.690	0.000	1.000
Mar	363.9	6.263	0.000	1.000
Apr	370.8	6.015	0.000	1.000
May	404.6	6.180	0.000	1.000
Jun	414.5	5.946	0.000	1.000
Jul	417.0	6.132	0.000	1.000
Aug	418.2	6.132	0.000	1.000
Sep	393.3	5.957	0.000	1.000
Oct	397.2	6.216	0.000	1.000
Nov	315.7	6.061	0.000	1.000
Dec	250.3	6.299	0.000	1.000
Year	4305.2	73.215	0.000	1.000

Figure 10-63 F-Chart Simulation

10.8.2 TRSNYS simulation

The TRNSYS components “Collectors”, “Pre-heat Storage tank” and “Hot Water Demand” settings are updated. The changed areas are marked by red boxed, seen in Figure 10-64, Figure 10-65 and Figure 10-66.

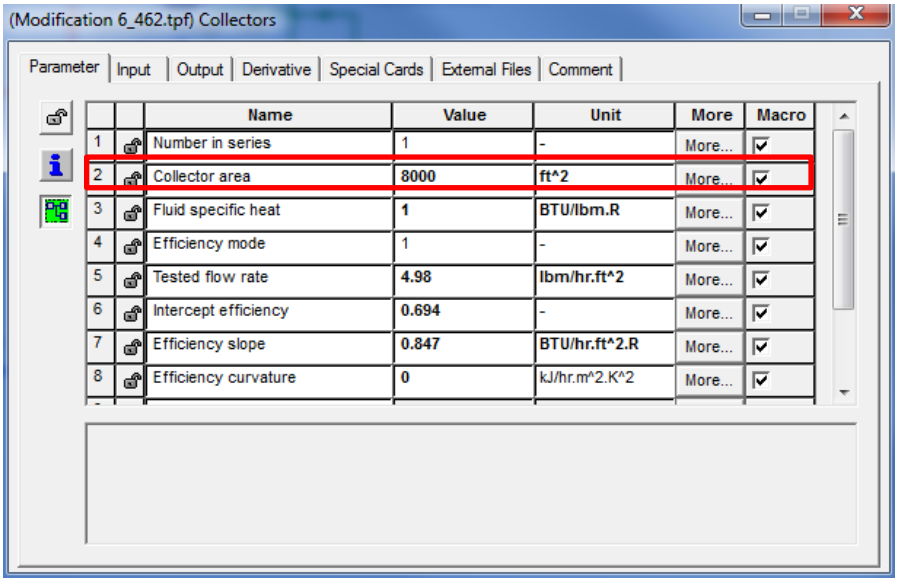


Figure 10-64 TRNSYS Component “Collectors” Settings

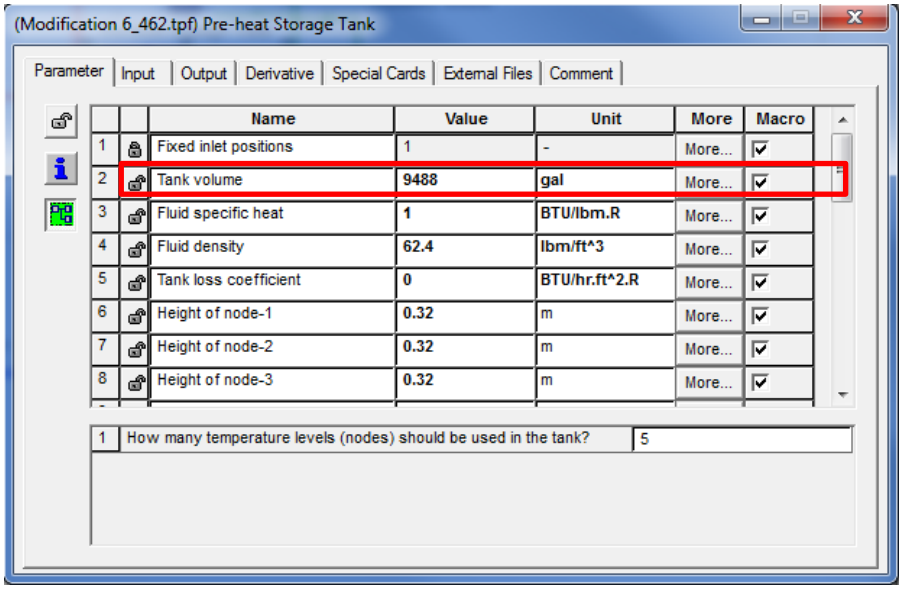


Figure 10-65 TRNSYS Component "Pre-heat Storage tank" Settings

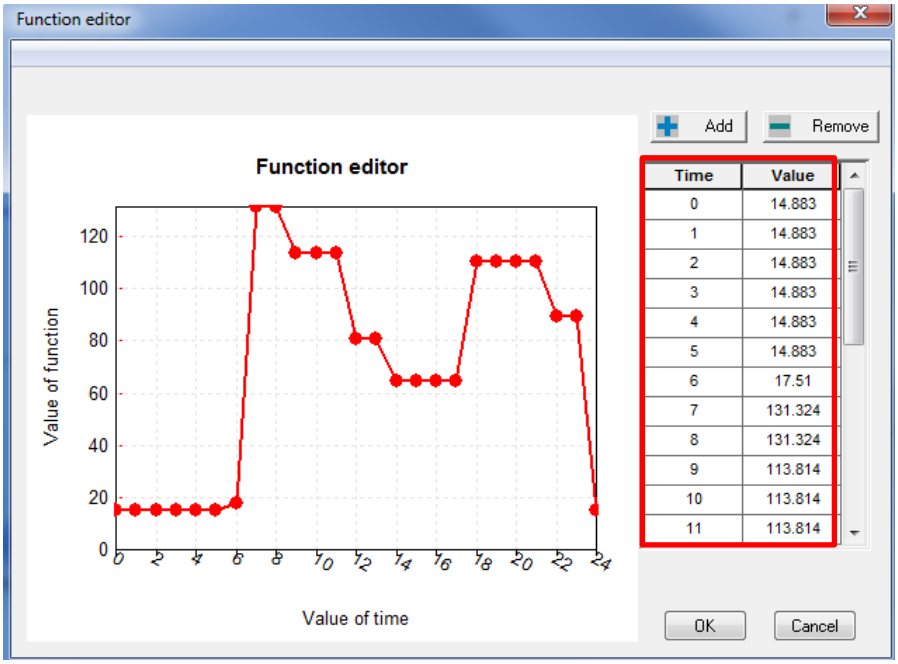


Figure 10-66 TRNSYS Component "Hot Water Demand" Settings

Figure 10-67 - Figure 10-70 present the simulation comparisons for ANALYSIS 6 (462 gallons/day) including Solar, Dhw, Aux and f factor. In Table 10-7, Solar shows -1.9% difference percentages, compared to F-Chart. Dhw and f factor show a difference percentage of 0.4% and 1.1 %, respectively.

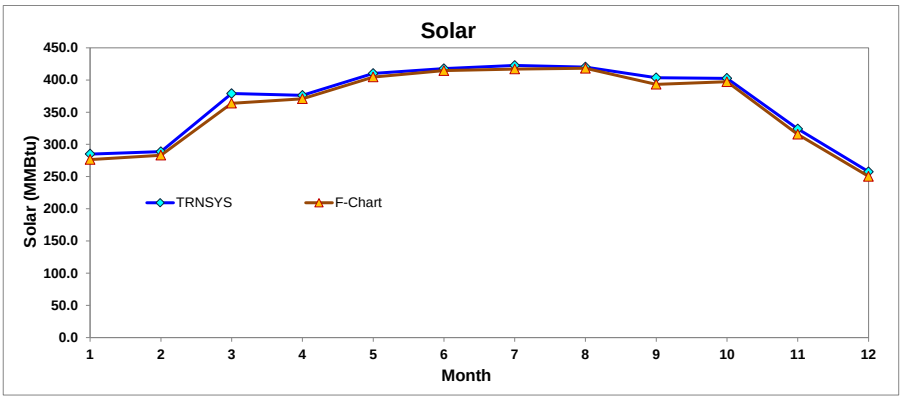


Figure 10-67 Monthly Total Solar Radiation Incident on the Collector Surface-ANALYSIS 6 (462 gallons/day)

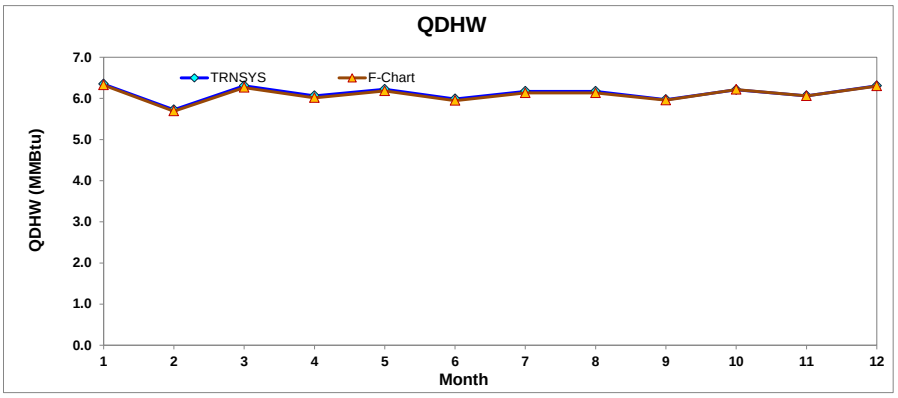


Figure 10-68Monthly Total Water Heating Demand -ANALYSIS 6 (462 gallons/day)

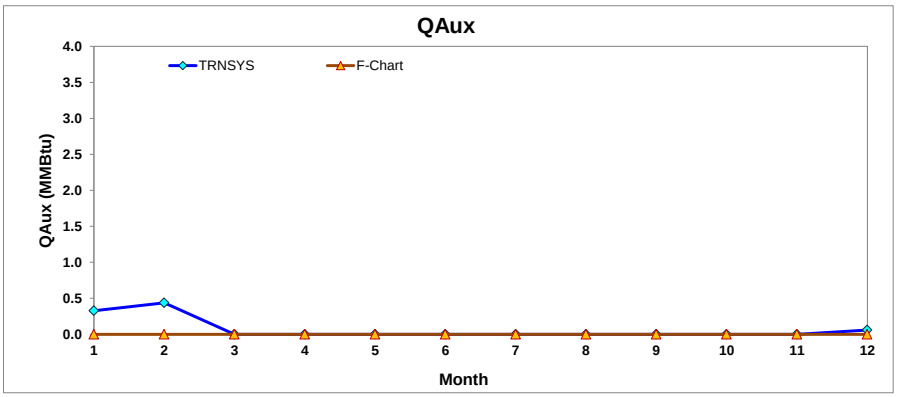


Figure 10-69Monthly Total Auxiliary Energy Required to Supply Domestic Water Heating Demand -ANALYSIS 6 (462 gallons/day)

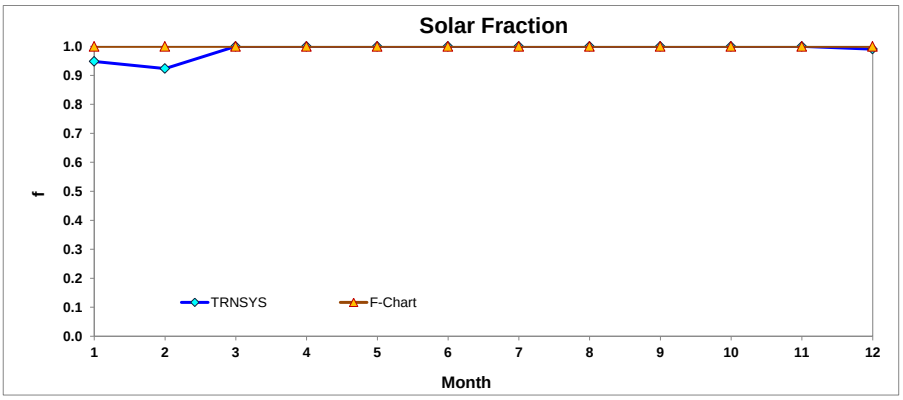


Figure 10-70Monthly Fraction of Domestic Water Heating Demands Supplied by the Solar Energy System -ANALYSIS 6 (462 gallons/day)

Table 10-7 Comparisons Data between TRNSYS and F-Chart ANALYSIS 6 (462 gallons/day)

	TRNSYS				F-CHART				Diff%			
	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (MMBtu)	QDHW (MMBtu)	QAux (MMBtu)	f	Solar (%)	QDHW (%)	QAux (%)	f (%)
Jan	284.958	6.347	0.328	0.948	276.400	6.323	0.000	1.000	-3.1%	-0.4%	N/A	5.2%
Feb	288.769	5.723	0.438	0.924	283.200	5.690	0.000	1.000	-2.0%	0.6%	N/A	7.6%
Mar	378.920	6.305	0.000	1.000	363.900	6.263	0.000	1.000	-4.1%	0.7%	N/A	0.0%
Apr	376.152	6.062	0.000	1.000	370.800	6.015	0.000	1.000	-1.4%	0.8%	N/A	0.0%
May	410.133	6.221	0.000	1.000	404.600	6.180	0.000	1.000	-1.4%	0.7%	N/A	0.0%
Jun	417.579	5.985	0.000	1.000	414.500	5.946	0.000	1.000	-0.7%	0.7%	N/A	0.0%
Jul	422.510	6.170	0.000	1.000	417.000	6.132	0.000	1.000	-1.3%	0.6%	N/A	0.0%
Aug	420.044	6.170	0.000	1.000	418.200	6.132	0.000	1.000	-0.4%	0.6%	N/A	0.0%
Sep	403.469	5.971	0.000	1.000	393.300	5.957	0.000	1.000	-2.6%	0.2%	N/A	0.0%
Oct	402.511	6.209	0.000	1.000	397.200	6.216	0.000	1.000	-1.3%	0.1%	N/A	0.0%
Nov	324.088	6.062	0.000	1.000	315.700	6.061	0.000	1.000	-2.7%	0.0%	N/A	0.0%
Dec	257.458	6.305	0.059	0.991	250.300	6.299	0.000	1.000	-2.9%	0.1%	N/A	0.9%
Year	4386.592	73.531	0.824	0.989	4305.200	73.215	0.000	1.000	-1.9%	0.4%	N/A	1.1%

10.9 Discussion

Figure 10-71 compares the f factor of SDHW system simulated by TRNSYS and F-Chart. It has shown that both results follow the same pattern and trend. As the daily hot water usage increases, the f factor equals to 1 or approximately 1. For daily hot water usage equals to 461 and 462 gallons/day, the f factor by TRNSYS simulation cannot achieve 1 because the storage tank volume is too large to fulfill the hot water demand only by solar collectors.

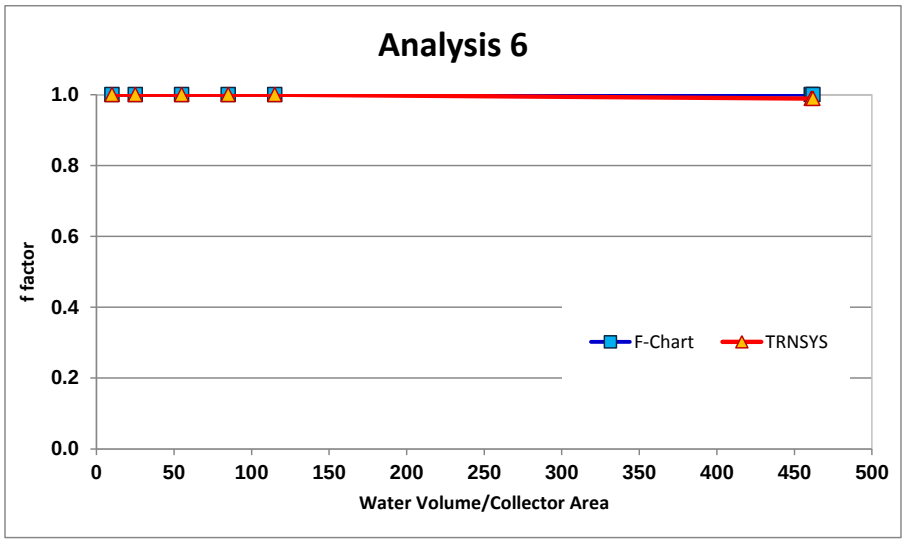


Figure 10-71 f Factor Comparisons between F-Chart and TRNSYS – ANALYSIS 6

11 SUMMARY

This report contains a comprehensive study for comparing SDHW system simulation variations by TRNSYS and F-Chart software. Base case and six analysis are studied to better understand the simulation variations caused by solar collector areas, water volume/collector area ratio and daily hot water usage. Since TRNSYS simulates transient system behavior, the component settings can affect some of the results. For example, the "weather" (Type 15-2) is used to read TYM2-Houston weather. Section 2 has already demonstrated certain differences exit when comparing the original TMY2 weather file and the ones from Type 15-2 reader. Furthermore, F-Chart does consider the hot water draw profile while TRNSYS does, which could result in obtaining different extra heating energy from heaters. The analysis results show that the difference percentages of TRNSYS and F-Chart software simulation are in the range of 0%-19.6%, depending on the solar collector area cases.

Figure 11-1 Comparison Summary of Simulation between F-Chart and TRNSYS for All the Analysis

	Settings		Reference	Base Case	Analysis 1				Analysis 2				Analysis 3				Analysis 4							Analysis 5								Analysis 6							
Flat-Plat Collector	No. of collector panels		64	2																																			
	Collector panel area	(ft^2)	1	32.04	40	40	40	40	400	400	400	400	4000	4000	4000	4000	40	40	40	40	40	40	40	400	400	400	400	400	400	400	400	4000	4000	4000	4000	4000	4000	4000	4000
	FR*UL	(Btu/hr-ft^2-F)	1.07	0.847																																			
	FR*TAU*ALPHA		0.78	0.694																																			
	Collector slope	(degree)	30	29.8																																			
	Collector azimuth	(degree)	0	0																																			
	Inc angle modifier constant		Values	0.25																																			
	Collector flow rate/area	(lb/hr-ft^2)	11	11																																			
	Collector fluid specific heat	(Btu/lb-F)	1	1																																			
	Test collector flow rate/area	(lb/hr-ft^2)	11	4.98																																			
	Test fluid specific heat	(Btu/lb-F)	1	1																																			
Active Domestic Hot Water System	Location			Houston																																			
	Water volume / collector area	(gallons/ft^2)		1.186	0.93	3	5.9	7.3	0.93	3	5.9	7.3	0.93	3	5.9	7.3																							
	Fuel			Elec																																			
	Efficiency of fuel usage	(%)		70																																			
	Daily hot water usage	(gallons)		70													50	51	55	85	106	107	115	10	25	55	85	115	146	147	150	10	25	55	85	115	461	462
	Water set temperature	(F)		120																																			
	Environmental temperature	(F)		71.6																																			
	UA of auxiliary storage tank	(Btu/hr-F)		0																																			
	Pipe heat loss			No																																			
	Tank-side flow rate/area	(lb/hr-ft^2)		11																																			
	Heat exchager effectiveness			0.5																																			
Water Storage Space and DHW System	Location		Austin																																				
	Water storage volume	(gallons)	1000																																				
	Building UA (0 if only DHW)		0																																				
	Fuel		Elec																																				
	Efficiency of fuel usage	(%)	100																																				
	Daily hot water usage	(gallons)	60																																				
	Water set temperature	(F)	140																																				
	Environmental temperature	(F)	68																																				
	UA of auxiliary storage tank	(Btu/hr-F)	7.6																																				
	Relative load heat exchanger size		1																																				
Annual f		F-Chart	0.719	0.744	0.798	0.877	0.909	0.917	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.930	0.917	0.895	0.754	0.675	0.671	0.644	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
		TRNSYS	TRNSYS	0.852	0.877	0.942	0.961	0.965	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.986	0.941	0.939	0.930	0.857	0.798	0.794	0.770	1.000	1.000	1.000	1.000	1.000	0.997	0.997	0.996	1.000	1.000	1.000	1.000	1.000	0.989	0.989
	(from 120F->100C)	% Diff		-14.5%	-9.9%	-7.4%	-5.7%	-5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	-1.2%	-2.4%	-3.9%	-13.7%	-18.2%	-18.4%	-19.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	1.1%

12 CONCLUSION

In this study it has been found that TRNSYS program gives a reasonable analysis for SDHW system compared to F-Chart program.

The comparisons show when solar collector area equals to 80 ft^2, TRNSYS simulations predicts more useful solar energy than F-Chart. The results have similar patterns and trend. This conclusion can be extended to the equivalent collector area range. In addition, when solar collector areas increase till quite large number, such as 800 ft^2 and 8000ft^2, the simulations from TRNSYS and F-Chart match very well. Some of them can even achieve 0% difference percentage. This demonstrates that TRNSYS simulations are reliable in those cases.

Haberl and Cho (2004) concluded that the difference percentage range is 1.1%-4.7%, based on their literature review. However, in this report, the difference percentages vary. There are certain simulation results falling in that range but the report demonstrates that 1.1%-4.7% range is not accurate. The difference percentages of comparisons can achieve 0% or larger than 4.7%, depending on the simulation input parameters' values.

13 REFERENCE

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Solar Energy Laboratory, 2009, TRNSYS 17 Manual.

Shariah, A.M. and Lof, G.O.G. (1996). Effects of Auxiliary Heater on Annual Performance of Thermosyphon Solar Water Heater Simulated Under Variable Operating Conditions. *Solar Energy*, Vol.60, No.2, pp. 119-126.

Solar Boiler™,1999, Solar Domestic Hot Water System Technical Specifications.

14 APPENDIX A: TRNSYS AND F-CHART COMPARISON REPORT FROM TESS MODELING GROUP

The TESS Modeling Group Simulated the Solar Domestic Hot Water System which is shown in Figure 14-1. Two-tank system is selected with a heat exchanger locating between two tanks. A temperature difference controller is adopted to control the temperature difference between solar collector and pre-heat tank. The detailed report is shown below.

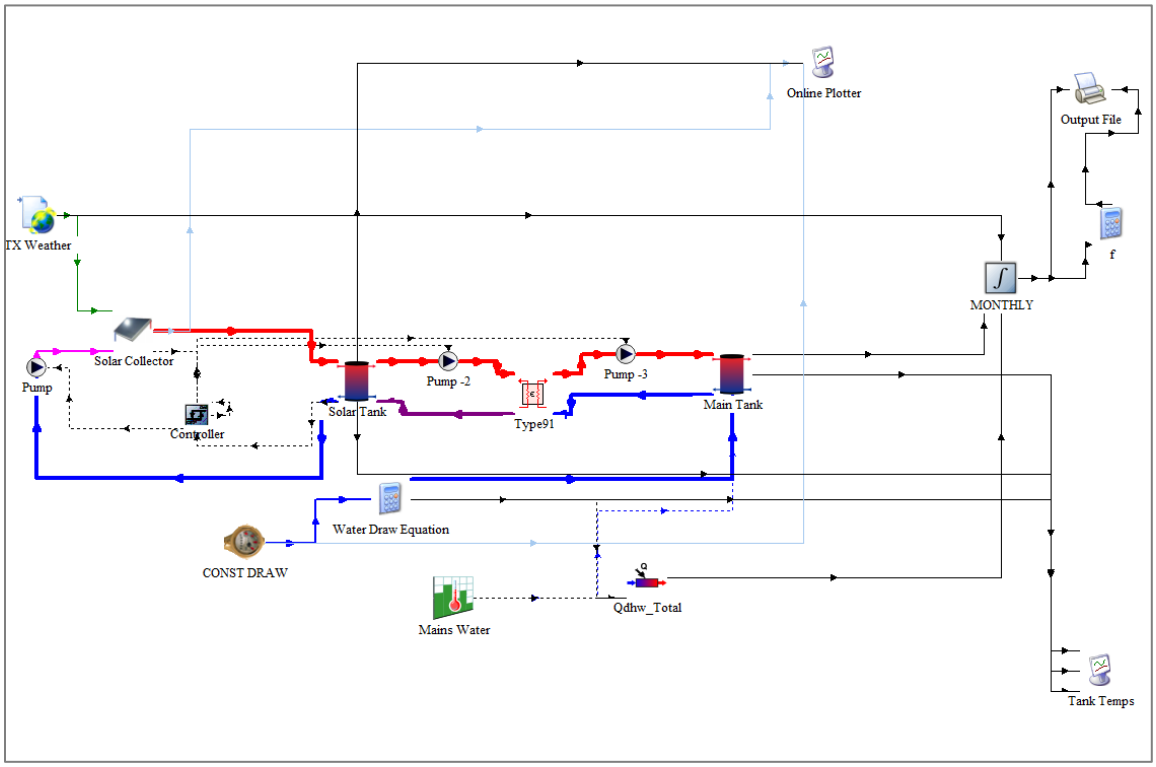


Figure 14-1 Solar Domestic Hot Water System Model by TESS

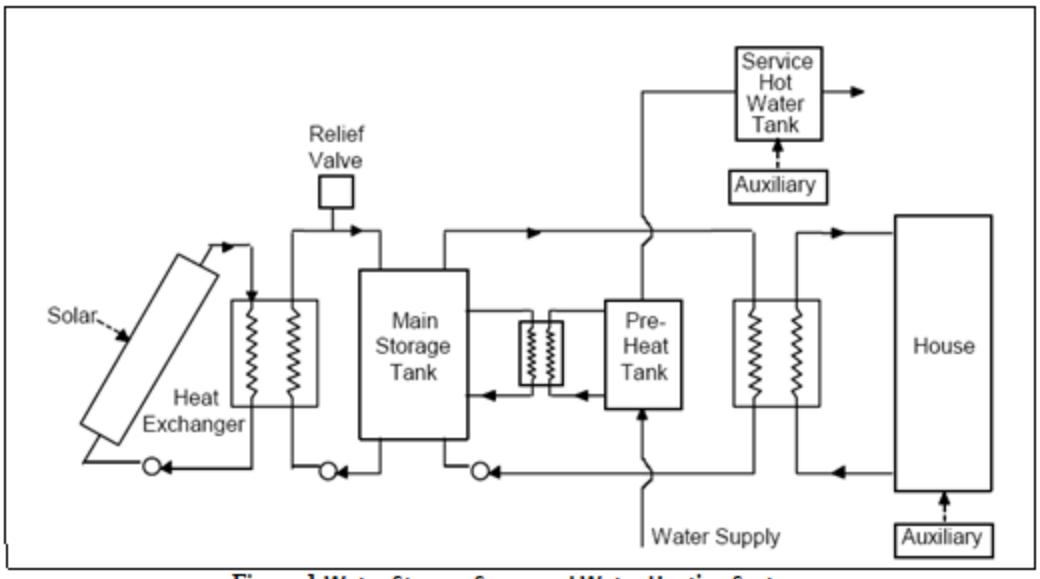


Figure 1 Water Storage Space and Water Heating System

```
1  City call number.............  16
2  Water storage volume.........  1000        GALLONS
3  Building UA (0 for DHW only)..  0          BTU/HR-F
4  Fuel (1=EL,2=NG,3=OIL,4=OTHER)  1
5  Efficiency of fuel usage.....  100         %
6  Domestic hot water (1=Y,2=N)..  1
7    Daily hot water usage.......  60          GALLONS
8    Water set temperature.......  140         F
9    Environment temperature.....  68          F
10   DHW storage tank size.......  450         GALLONS
11   UA of aux storage tank......  7.6         BTU/HR-F
12 Pipe heat loss (1=Y,2=N).....  2
13   Inlet pipe UA...............  5           BTU/HR-F
14   Outlet pipe UA..............  5           BTU/HR-F
15 Relative load HX size.........  1
16 Collector-storage HX (1=Y,2=N)  2
17   Tank side flowrate/area.....  11          LB/HR-FT2
18   Heat exchanger effectiveness  .5


1  Number of collector panels....  64
2  Collector panel area..........  1            FT2
3  FR*UL (test slope)............  1.07         BTU/HR-FT2-F
4  FR*TAU*ALPHA (test intercept).  .78
5  Collector slope...............  30           DEG
6  Collector azimuth (South=0)...  0            DEG
7  Incidence angle mod TYPE(8-10)  8
8    Number of glazings..........  1
9    Inc angle modifier constant.  0
10   Inc angle modifier value(s).
  1   .999  .998  .995  .981  .953  .882
  .7  .35  0
11 Collector flowrate/area.......  11           LB/HR-FT2
12 Collector fluid specific heat.  1            BTU/LB-F
13 Modify test values (1=Y,2=N)..  2
14   Test collector flowrate/area  11           LB/HR-FT2
15   Test fluid specific heat....  1            BTU/LB-F

   *** WATER STORAGE SYSTEM ***
```

** FLAT PLATE COLLECTOR **

	SOLAR MMBTU	HEAT MMBTU	DHW MMBTU	AUX MMBTU	F
JAN	1.7	0.0	1.7	1.1	0.34
FEB	1.9	0.0	1.6	0.8	0.48
MAR	2.7	0.0	1.7	0.6	0.63
APR	3.0	0.0	1.7	0.4	0.75
MAY	3.3	0.0	1.7	0.3	0.81
JUN	3.4	0.0	1.7	0.2	0.88
JUL	3.4	0.0	1.7	0.2	0.88
AUG	3.2	0.0	1.7	0.3	0.83
SEP	2.8	0.0	1.7	0.4	0.76
OCT	2.5	0.0	1.7	0.6	0.63
NOV	1.8	0.0	1.7	1.0	0.42
DEC	1.4	0.0	1.7	1.3	0.27
YR	31.1	0.0	20.3	7.3	0.64

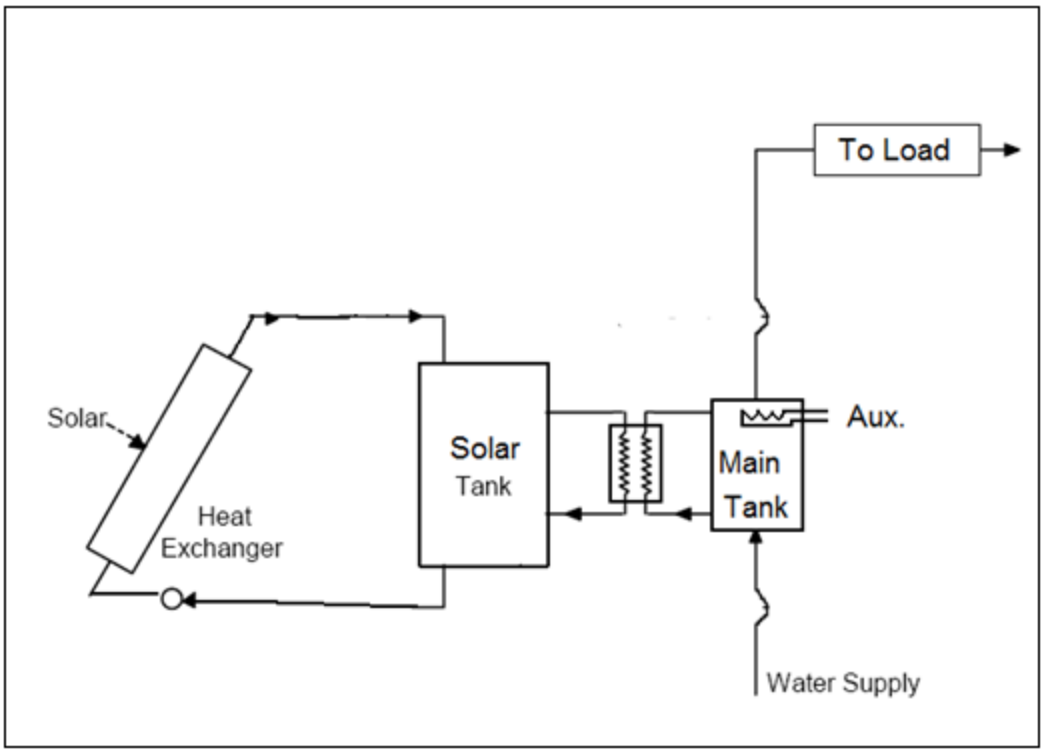


Figure 2 Configuration for TRNSYS Simulation

Figure 2:

Ambiguities and Assumption

1. The heat exchanger between the collector loop and the Solar Tank was ignored
2. The heat exchanger between the Solar Tank and the Main Tank were assumed to have pumps with flowrates that were equal in size to the collector pump.
3. No third 'Service Hot Water Tank' with auxiliary as shown in Figure 1. The auxiliary energy was assumed to be in the Main Tank in order to meet the setpoint.
4. The size of the Main Tank is 80 gallon.

5. The storage volume of the Solar Tank is assumed to be proportional to the area of the collector instead however, this may be changed to accommodate the older fChart parameter.
6. fChart assumes a constant water draw, and a constant water draw, based on the amount of daily DHW was assumed for the system.
7. fChart uses the monthly, daily average for weather and radiation values while the TRNSYS simulations used the TMY2 data for Austin, TX.

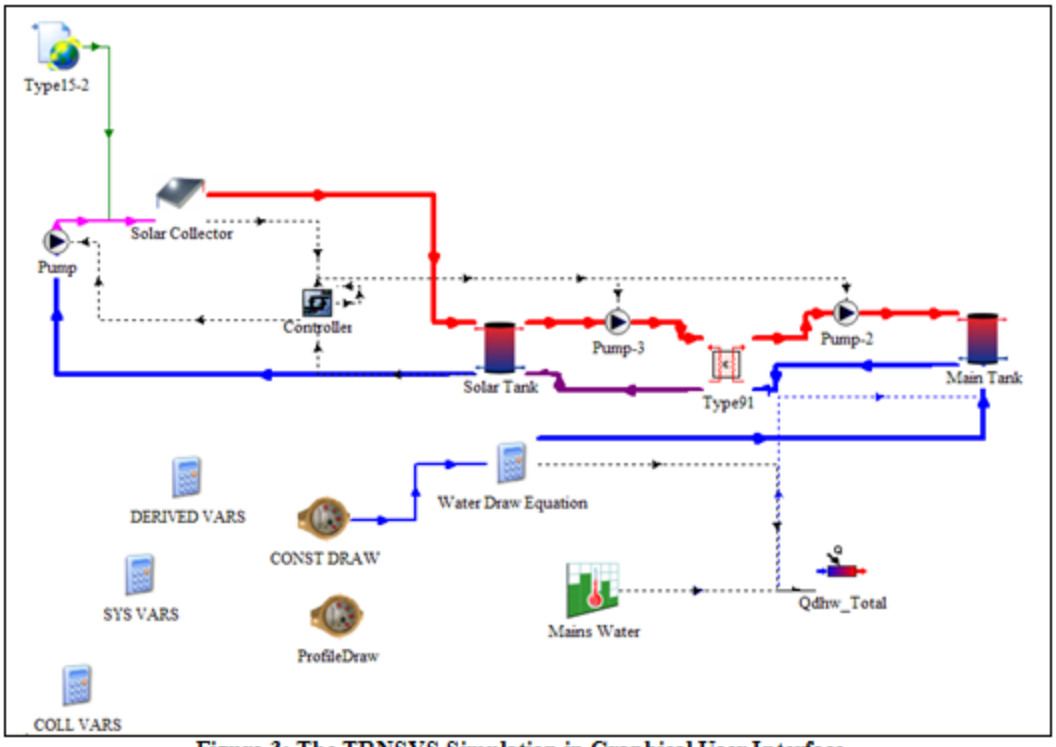


Figure 3: The TRNSYS Simulation in Graphical User Interface

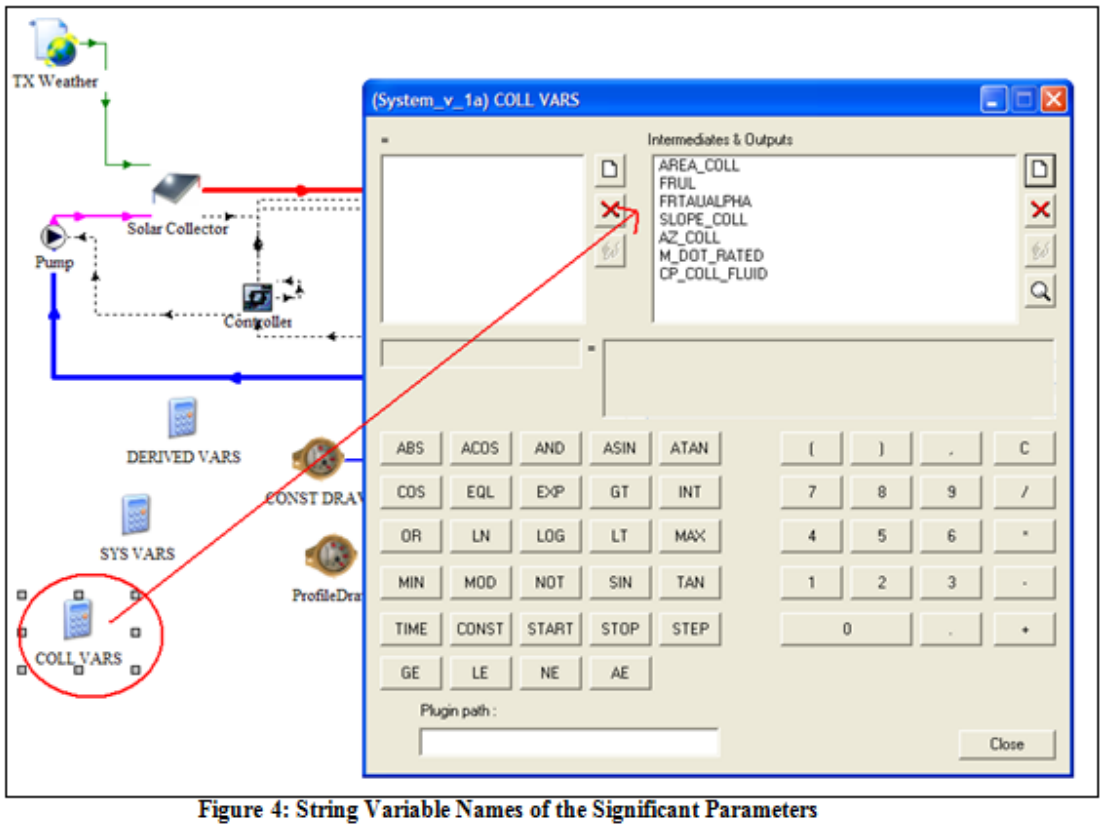


Figure 4: String Variable Names of the Significant Parameters

```
* EQUATIONS "COLL VARS"
*
EQUATIONS 7
AREA_COLL = 6 !m^2
FRUL = 6.075*3.6  !kJ/hr.m^2.K
FRTAUALPHA = 0.78
SLOPE_COLL = 30
AZ_COLL = 0
M_DOT_RATED = 50 !kg/hr.m^2
CP_COLL_FLUID = 4.19 !kJ/kg.K

*-------------------------------------------------------------

* EQUATIONS "SYS VARS"
*
EQUATIONS 7
STOR_RATIO = 0.075 !m^3/m^2
DHW_LOAD = 227 !LITERS
VOL_MAIN = 0.3 !m^3
SETPOINT = 60 !deg. C
T_ENVIR = 20 !deg. C
TANK_UA = 14.4 !kJ/hr.K
HX_EFF = 0.5
```

```
*-------------------------------------------------------------------

* EQUATIONS "DERIVED VARS"
*
EQUATIONS 3
FLOW_PUMP = AREA_COLL*M_DOT_RATED
VOL_TANK = STOR_RATIO*AREA_COLL

*-------------------------------------------------------------------
```

Figure 5: The String Variable Names in the TRNSYS Input File

Considerations, Questions, and Concerns

1. Implementation of a tempering valve to temper the hot water during the high solar months with the cool mains water?
2. Is the current configuration with the external heat exchanger between the tanks sufficient?
3. Tank U-value is used for the tanks, Tank-UA-value is used for the Type6 auxiliary heater for the DHW calculations, or an energy factor input may be implemented for the tanks upon request.
4. The TRNSYS simulation currently utilizing the quasi-SI units system, but can easily be changed to English unit system upon request.
5. The IAM's match the listed FChart IAM's and are referenced in an external text file.
6. TMY3 files to be implemented into the program?

Output File

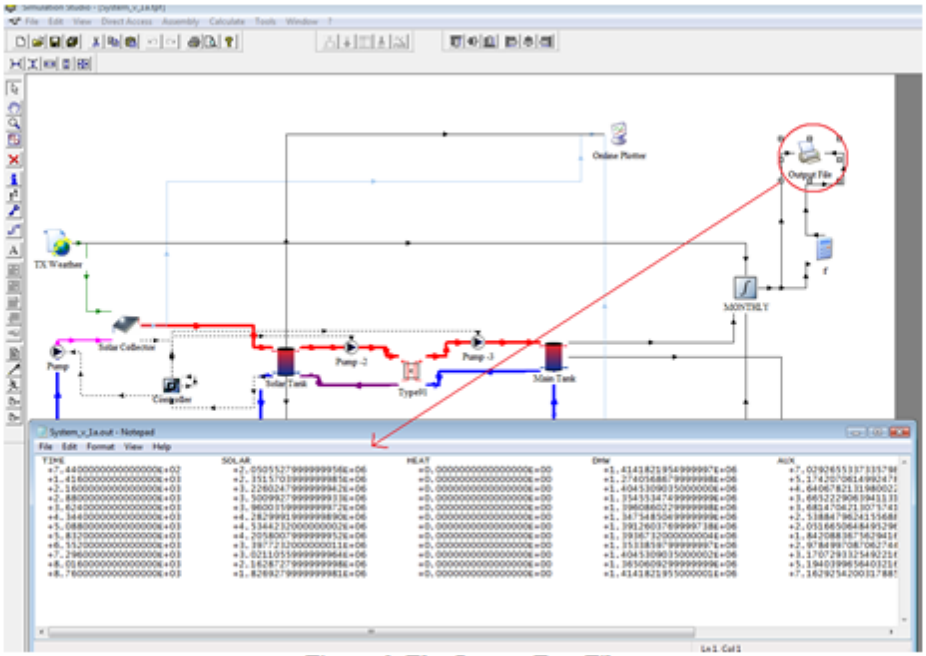
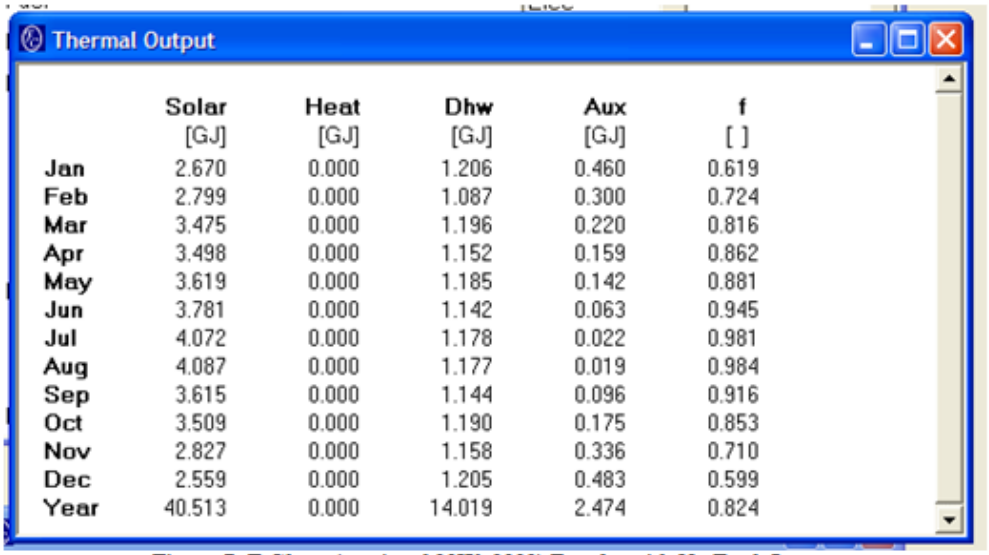


Figure 6: The Output Text File

Results

Table 1: TRNSYS Simulation Results with No Losses

	SOLAR	HEAT	DHW	AUX	f
Jan	2,050,553	-	1,204,463	464,535	0.61
Feb	2,351,570	-	1,083,908	331,510	0.69
Mar	3,226,025	-	1,192,669	297,362	0.75
Apr	3,500,993	-	1,148,489	179,212	0.84
May	3,960,036	-	1,182,350	119,153	0.90
Jun	4,282,999	-	1,139,929	51,313	0.95
Jul	4,534,423	-	1,176,453	16,826	0.99
Aug	4,205,801	-	1,179,401	22,418	0.98
Sep	3,397,723	-	1,147,063	92,205	0.92
Oct	3,021,106	-	1,192,669	90,420	0.92
Nov	2,162,873	-	1,161,330	249,074	0.79
Dec	1,826,928	-	1,204,463	460,775	0.62
Year	38,521,030	-	14,013,189	2,374,804	0.83

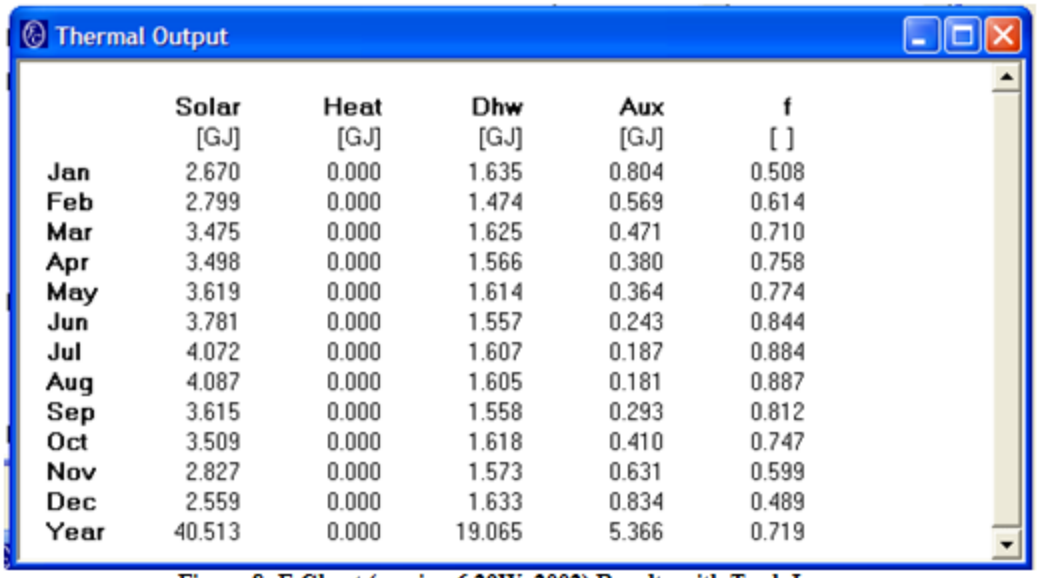


	Solar [GJ]	Heat [GJ]	Dhw [GJ]	Aux [GJ]	f [ ]
Jan	2.670	0.000	1.206	0.460	0.619
Feb	2.799	0.000	1.087	0.300	0.724
Mar	3.475	0.000	1.196	0.220	0.816
Apr	3.498	0.000	1.152	0.159	0.862
May	3.619	0.000	1.185	0.142	0.881
Jun	3.781	0.000	1.142	0.063	0.945
Jul	4.072	0.000	1.178	0.022	0.981
Aug	4.087	0.000	1.177	0.019	0.984
Sep	3.615	0.000	1.144	0.096	0.916
Oct	3.509	0.000	1.190	0.175	0.853
Nov	2.827	0.000	1.158	0.336	0.710
Dec	2.559	0.000	1.205	0.483	0.599
Year	40.513	0.000	14.019	2.474	0.824

Figure 7: F-Chart (version 6.29W, 2002) Results with No Tank Losses

Table 2: TRNSYS Simulation Results with Tank Losses

	SOLAR	HEAT	DHW	AUX	f
Jan	2,050,553	-	1,414,182	702,927	0.50
Feb	2,351,570	-	1,274,057	517,421	0.59
Mar	3,226,025	-	1,404,531	464,068	0.67
Apr	3,500,993	-	1,354,553	366,522	0.73
May	3,960,036	-	1,396,086	368,147	0.74
Jun	4,282,999	-	1,347,549	253,885	0.81
Jul	4,534,423	-	1,391,260	205,167	0.85
Aug	4,205,801	-	1,393,673	184,209	0.87
Sep	3,397,723	-	1,353,386	297,850	0.78
Oct	3,021,106	-	1,404,531	317,073	0.77
Nov	2,162,873	-	1,365,061	519,404	0.62
Dec	1,826,928	-	1,414,182	716,293	0.49
Year	38,521,030	-	16,513,052	4,912,964	0.70



	Solar [GJ]	Heat [GJ]	Dhw [GJ]	Aux [GJ]	f [ ]
Jan	2.670	0.000	1.635	0.804	0.508
Feb	2.799	0.000	1.474	0.569	0.614
Mar	3.475	0.000	1.625	0.471	0.710
Apr	3.498	0.000	1.566	0.380	0.758
May	3.619	0.000	1.614	0.364	0.774
Jun	3.781	0.000	1.557	0.243	0.844
Jul	4.072	0.000	1.607	0.187	0.884
Aug	4.087	0.000	1.605	0.181	0.887
Sep	3.615	0.000	1.558	0.293	0.812
Oct	3.509	0.000	1.618	0.410	0.747
Nov	2.827	0.000	1.573	0.631	0.599
Dec	2.559	0.000	1.633	0.834	0.489
Year	40.513	0.000	19.065	5.366	0.719

Figure 8: F-Chart (version 6.29W, 2002) Results with Tank Losses